THE
Engineering Review.

Published Monthly. **Edited by C. EDGAR ALLEN.**

Vol. XV. **DECEMBER, 1906.** **No. 6.**

All communications relating to articles, MSS., terms and payment for same, etc., books and catalogues for review should be addressed to

The EDITOR,
"Engineering Review,"
104, High Holborn, London, W.C.

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THE ENGINEERING REVIEW CO., Ltd.,
104, High Holborn, LONDON, England,

To whom all cheques, drafts and money orders should be made payable.

Managing Director:—Charles H. Luke.

Telephone No.: 1049, HOLBORN.

Telegraphic and Cable Address: "COMPELLING, LONDON."

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SUBSCRIPTION RATES.—9/- per annum. Post free to any part of the world.

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The Engineer to the World at Large.

THE inaugural meeting of the eighty-eighth session of the Institution of Civil Engineers was held on Tuesday, November 6th, when the President, Sir Alexander Kennedy, LL.D., F.R.S., delivered an address to the members.

Sir Alexander Kennedy took for his subject the relation of the engineer and engineering to the world at large. In relation to science he pointed out that not a few engineers spend their whole lives in what is really scientific work, while nominally only earning their daily bread in ordinary mechanical pursuits. He thought that the special nature of the problems with which they had to deal ought to tend directly to produce tolerant and broad-minded citizens.

He was sorry that the paths of the artist and the engineer seemed too often to be divergent, but pointed out that as soon as engineering works were treated on their own merits and not as if they were mistaken imitations of other things, it would be found that they could possess even artistic as well as other merits. Everyone now would recognise that there was a dignity in a *Dreadnought* which was almost majestic, and that a modern liner formed really as fine a subject for a picture as a full-rigged ship. The proverb that art is long and life short was truer when reversed. Life continued through all the centuries, art and its "laws" changed with each of them.

He spoke at some length about the relation of the engineer to nature, especially in connection with water-power utilisation and mountain railways. No apology was needed for undertakings which gave employment to hundreds of men in places where hitherto no one could maintain himself, or for substituting industrial villages for ruined huts. But the "mountain railways" of Switzerland—and of Snowdon—were merely a product of tourist madness, wholly unnecessary, serving no public benefit whatever, and in many cases, which he instanced, likely to cause irreparable damage to natural beauty.

In relation to law he pointed out how frequently it was necessary for the engineer, in relation to specifications and contracts, to carry on his work in a legal spirit, and discussed the question of the drawing-up of specifications from the points of view both of the manufacturer and the consultant. It was a point not authoritatively settled whether engineering was a "profession" or not, but he urged his colleagues to act always as if they belonged to a profession in which the organisation and etiquette were as strict as in law and medicine.

Engineering was always in close touch with industrial life, and he urged that the present time was specially suitable for taking practicable steps towards the establishment of joint trade committees, organised and arranged to act with full powers whenever required, under appointed leaders, for the purposes of industrial arbitration. Such machinery should be got completely ready in a quiet time like the present, so that it might act automatically before and not after the stage of mutual recrimination and vituperation had commenced.

In concluding he spoke of the future of engineering and of the possibility—which he thought a very small one—of finding anything in mechanical science corresponding to the "survival of the fittest," or any traceable lines along which mechanical evolution took place. He thought that "invention," however, formed such a disturbing influence in engineering evolution that any prophecy on evolutionary lines was impossible. It was still more useless to attempt to forestall the future by trying to do to-day what it is supposed that other people may try to do twenty years hence. The *Great Eastern*, broken up for scrap almost within hail of the *Carmania*, was a pathetic tragedy from this point of view, in engineering.

Metric Measures in Industry and Commerce.

By R. H. SMITH.

THE conversion of Messrs. Kynock & Co. to the use of metric measures throughout their manufactures is a sign that this reform, which has hung fire through so many years, may come upon us almost suddenly and almost unexpectedly. The question has been rather thrust into the background during the last few years by the forced prominence of other matters of greater public urgency. But reforms and revolutions have a habit of passing through three stages, the first, a long, weak struggle marked by many successive defeats; the second, a period of apparent inanition, during which, however, a great silent growth is gradually proceeding; and the third, a sudden rush to victory. There has now been fairly inaugurated a new period of radical reforms in the direction of efficiency, and it need surprise no one if the legalisation of metric measures as standards, which shall become compulsory within a specified number of years, be an accomplished fact before the end of 1907.

In considering the merits of the question it is essential to recognise at the outset that it is not a choice between decimal and duodecimal systems that has to be made. There exists no rival duodecimal system either in England or elsewhere. We divide our shillings into twelve pennies, but our £1 is decimally divided to shillings, and binary division is applied to the penny. The foot is divided into twelve inches, but neither the inch, nor the yard, nor the mile is similarly divided. In only one little used set of weight measures does division by twelve appear, and there only once. Generally throughout existing British measures division by twelve is far less used than that in other ratios; it is less used than division by ten, and a very great deal less than binary division. Therefore do not let us be drawn away from the real issue by discussion of the relative merits of decimal and duodecimal division. No one is mad enough to propose to convert our system of decimal numeration and notation to any other arithmetic base. The greatest benefit derivable from the metric system is the enormous practical convenience of making the divisions of our measures throughout and systematically coincident with our numeration, which cannot be altered from its decimal base-ratio.

Another trail on which the discussion is often led away must also be pronounced wholly irrelevant and even frivolous, namely, the supposed (and originally proposed) ratio of the metre to the earth's quadrant and its ratio to the seconds pendulum. Neither the metre, nor the inch, nor the foot, has any exact integral ratio to the earth's diameter or to the seconds pendulum, or to any particular radiant wave-length, or to any other particular physical phenomenon. Nor would there be the smallest practical utility in its having any such ratio: no more than if it had an exact ratio to the average height of the mountains in the moon.

The chief, and indeed the only, characteristic of British measures is its absolute want of system of any kind; its character of being an entire jumble of discordant inanities. There really exists no one who has any working acquaintance with our measures who admires them or attempts to defend them as a system; no one who denies the need of reform. What is not commonly recognised is that once reform to

a *harmonious system* is definitely decided on, there is not the slightest chance of any responsible Government or of any really practical politicians eventually deciding for any other *system* than the metric. All the difficulties and the practical objections to reform are really obstacles to any change at all. There are real and substantial difficulties to be overcome in introducing a change of any kind. But they are of the same magnitude very approximately whether the change be to any one or to any other system — so approximately so that it would involve us in impossibly complicated calculation to discover which change involved least difficulty and loss.

One asserted difficulty is that of teaching workmen in factories to use the new measures correctly. This first objection is a mere delusion of the imaginations of the objectors. No more complete myth could be invented. The opposite has been demonstrated almost times without number. Forty years ago, when workmen were, on the average, duller and less educated than they are now, Sir Joseph Whitworth introduced decimal division of the inch throughout all his engineering work without the slightest difficulty on the part of his workmen. In many other engineering works in England and America similar changes have been introduced, and always without trouble from the workmen. The change has been effected in every workshop throughout Germany, Switzerland, Belgium, and Italy, and always with the same experience. The reason is evident. On the change being made, new divided rules (scales) have to be provided for the men, and they have to be forbidden to use the old rules. All the men have to do in their work is to measure off on their material the dimensions prescribed on the drawings, &c. The divisions on the new scale are as easy to read as those on the old scale. It does not matter to them in the least whether these divisions represent fractions of inches or of feet or of meters. For a day or two they will be a little slow in interpreting on the scale the dimensions specified on the drawings; but this slowness of interpretation wears off entirely in less than a single day in the case of a first-class man. A quarter of a century ago there was still a good deal of judging sizes by eye and weights by poising in the hand. Such acquired intuitive faculty of measurement could not, of course, be rapidly, or at all easily, translated into new terms. But this no longer exists in modern workshops. Everything is dealt with by methods of exact measurement by suitable measuring apparatus or instrument. There is no longer any room for the exercise of intuitive measuring faculty on the part of the manufacturing artisan.

The case is somewhat different with designers of machinery and all that class of technical experts who have to exercise their wits in making rapid mental estimates of correct sizes and quantities and values. It may probably be true that design of important parts in new machines by "rule of thumb" is no longer practised. Perhaps it would be still truer to say that those who still practice it do not require, and do not deserve, practical consideration by the reformers. But a distinction must be drawn between "rule of thumb" and "intuitive perception." Prolonged work in any department of technology produces instinctive knowledge of what is wrong and what is right in vast multitudes of detail matters. This kind of perception is applied to the design of at least three quarters of the detail dimensions of every machine produced from the drawing office, these being settled without any numerical calculation. This instinct is quite akin to that which guides an experienced writer or speaker in the choice of his phrases without the need of consciously applying the rules of grammar to their construction. It is on the whole, the *surest* kind of technical knowledge that exists, its one disadvantage being that it is, of course, apt to be greatly coloured by prejudice. Now so far as this kind of expertness is applied to the choice of *numerical* dimensions, designing in

metric measures is to the man accustomed to inch, foot, lb. and ton, like speaking or writing in a new language. For a very long time, perhaps for some years, he may continue to *think* in his old terms, and it will be only after he has actually finished his estimate of the detail in hand that he will translate it into the new measures. The present writer is inclined to believe that this is the most serious practical objection to change in our measures. It is pure folly on the part of enthusiasts for metric measures to ignore it. As well ignore the acquired capacity of the Dutch nation for speech and writing and reasoning in the Dutch tongue in any crusade for establishing modern German as the legalised language of Holland. It represents a large proportion of the expert mental capital of British engineers and tradesmen. To sacrifice it ruthlessly and without consideration would be "scrapping gone mad."

Fortunately, however, a great deal of this intuitive perception exercises itself, at least in engineering, not in choosing numerical magnitudes but *in selecting proportions*. The real process of modern design consists in rigid calculation of one or two or three score of *leading dimensions* and then filling in all the minor dimensions by help of the above intuitive perception of correct proportion. The former part of the process is as easy in metric as in any other measures, or rather easier. The latter part is carried out for the most part on the drawing board, that is to say, graphically without regard to any particular system of measures. In regard to these latter the main function of the chief draughtsman is to *criticise*: he makes his tour of the tables and as he looks at each drawing his keen eye detects at a glance, those parts which offend his instinctive sense of due proportion. The wrong proportions being rectified, it is for the assistant to adjust the corrected dimensions to whatever system of measures is being used.

This loss of expert mental capital is the first real solid objection to change. The second is a strictly analogous loss of material capital. It also is real and serious; it must be justified in reason and not simply ignored or laughed at or sneered at, by the reformers. An illustration of it is the cost of the new millimetre rules and other measuring instruments to be supplied to the artizans. It is a fairly good illustration in showing the true proportions of the loss. If the measuring instruments used by any sort of artizan in an engineering works be examined, it will be found that only from 5 to 10 per cent. of them are constructed with reference to any particular system of measurement, inch or millemetre, or other. Those that are constructed for one particular set of measures may cost about 20 per cent. of the man's weekly wage, that is, from $\frac{3}{8}$ to $\frac{1}{2}$ of 1 per cent. of his yearly wage. As a large proportion of the employees do not use any such instruments, it is safe to say that $\frac{1}{4}$ of 1 per cent. of the yearly wage bill would defray the total cost of the renewal of measuring instruments of this sort. This means from $\frac{1}{10}$ to $\frac{1}{8}$ per cent. of the value of the yearly turn over.

Another example is the capital sunk in machine tools. The majority of these have attached to them no apparatus for gauging the work to any specific sizes expressed in any one or other set of measures. Such tools are saws, rolling mills, steam hammers and hydraulic presses, riveters, shearing machines, planers, slotting and shaping machines, milling machines. Drills are only used with drills ground to standard sizes. The standard sizes could be changed in about half these drills by simple re-grinding, the process every such drill undergoes every time it needs re-sharpening. Twist drills, however, would need remaking. A complete set of new twist drills for a drilling machine may cost from 4 to 8 per cent. of the cost of the machine itself, along with its foundation and driving gear. Punching machines are similar to drills in this respect. Again, apart from screwing machines, but inclusive of hollow mandril lathes, nearly one-half of the lathes in use have no attachment directly enabling the

turner to cut to any specific sizes—no means of cutting to standard gauges incorporated in the machine itself. About half in number, and perhaps three-quarters in total value, of all the lathes in use are fitted with leading screws cut for inch dimensioning. Mr. Alex. Siemen's has shown that millemetre dimensions can be produced by help of inch leading screws with an accuracy greater than is required in the great bulk of ordinary tooling. But supposing this were not so, new leading screws could be fitted to lathes at a cost certainly less than one-tenth of the total lathe value. It is certain that if metric measures were made compulsory by legislation not half the lathes in the country having leading screws would be converted or changed in any way.

With most modern machine tools certain gauges and "jigs" are used, and in British practice these have been made mostly to inch dimensions. It is a mistake to suppose that the legal introduction of metric measures would necessitate the changing of such of these as have been made for particular individual machines, and these constitute the great bulk of them. Drilling jigs may be taken as the single exception proving this rule. On the other hand the works would need to be supplied with new standard gauges to metric measures. These are expensive, but they are the reverse of numerous. Small and very large engineering works might spend £40 and £500, or £600, respectively in the purchase of these new standards.

These four items fairly represent the classes of total loss to be incurred in introducing reform. Their magnitude will vary from trade to trade, and will vary vastly more in the imaginative estimates of possessors of plant who object to change. It is to be noted that these losses are necessarily incurred whatever the change may be, whether it be to the metric measures or to measures based on the decimalisation of the inch or of the foot, whether it be to a rational and consistent system or to one completely senseless.

The seriousness of a loss of capital can be judged rationally only in relation to the speed of production, or the ratio of annual turn-over to fixed capital sunk in the business. This ratio varies in different industries from one-tenth up to twice the capital employed. In manufacturing trades the average ratio appears to be somewhat below unity, and in that part of engineering devoted to the making of machinery it is between $\frac{3}{4}$ and 1.

Putting these things together, one may make a very rough estimate of the sacrifice of material capital involved in the reform, as (1) in workmen's instruments and apparatus of that class from a $\frac{1}{4}$ to $\frac{1}{2}$ a day's output; and (2) in machinery in the higher skilled manufactures from 2 to 3 days' output. Of course this in the aggregate represents an enormous sum of money. But that is a wrong way of looking at the matter. In the first place it is distributed among an enormous number of people. But it is even more important to remember that by little extra effort in thrift, the loss of half a week may be made up in a month's time, and also that the introduction of more economic method and organisation may make it up in perhaps less than a month.

The advantages to be gained have been described so frequently that they need not be again enumerated here. The two great points to be remembered about them are, that they will endure in beneficent activity through all time to come, and that in the education and training of our children, and of our children's children, they will set free a large proportion not only of school TIME, but of latent mental energy for development on really useful lines.

The Design and Construction of Mechanical Calculators.—III.

By WILLIAM J. GOUDIE, B.Sc., A.M.I.Mech.E.

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An idea of the facilities which the foregoing rules afford for the rapid adjustment of an interlinked set of scales can now be obtained, from the following application of them to the primary arrangement of Fig. (9),* which, to avoid confusion with the final arrangement, has been redrawn dotted in Fig. 11.

According to rule IV. the R and S scales can be shifted a distance a to the right, till R = 20,000 comes in line with $M = 200$. By the same rule the N and Q scales can be shifted a distance b to the right, till $N = 1$ comes in line with $M = 200$. By rule V. the P scale can be shifted a distance c to the right, till $P = 10$ coincides with $M = 10$, provided that the Q scale is shifted again the same distance c to the left. Finally, by the same rule, the N scale can be shifted a distance d to the left, till $N = 1$ coincides with $Q = \cdot1$; provided that the S scale is again shifted the same distance d to the right. When this is done, $S = 10$ should coincide with $R = 21\cdot53$.

By means of these adjustments all the scales in their correct relative positions are brought within the limiting length of the M scale; and allowing a margin of about $\frac{1}{4}$ in. at each end, the primary length of the instrument is thereby reduced from $9\frac{3}{8}$ in. to $4\frac{1}{2}$ in., or about 50 per cent. The choice of the logarithmic base scale, to conform to the limiting conditions of scale dimensions, can now be made. The upper or "A" scale of a 10-in. slide rule has a unit about 5 in. long. Taking half of this as the base or R scale unit, it will be found that the M scale length is about $9\frac{3}{8}$ in., so that allowing a $\frac{1}{4}$-in. margin again at the ends, the length of the instrument will be fully 10 in.

In order to simplify the work of setting out the full-sized scale arrangement, the preliminary adjustment of the primary arrangement, as shown here, should be made so as to bring two principal scale-divisions on each pair of traversing scales in line with each other. The exact position of the scale or index line finally adjusted can then be easily ascertained by calculation. Sometimes it is possible to hit upon a provisional arrangement of full-sized scales, and to adjust these directly without the aid of the primary arrangement, but as a rule the latter will be found to afford the easiest and quickest means of arriving at the desired result.

The Disk Calculator.—The next subject to be considered is the design of the circular equivalent of the straight slide instrument, already incidentally referred to, and illustrated in its most elementary form in Fig. 3.* This type may take two different forms.

Referring to Fig, 11, let the point O on the datum line $Y\,Y$, where it crosses the R scale line $A\,B$, be fixed on the paper, and let this scale line be bent round into a circle, to which the line $A\,B$ in the initial position is tangent at O, as shown in Fig. 12. The line $Y\,Y$ then forms the vertical diameter of this derived circle, which may be taken to represent the circumference of a fixed disk.

* Vol. xv., p. 262.

* Vol. xv , p 185.

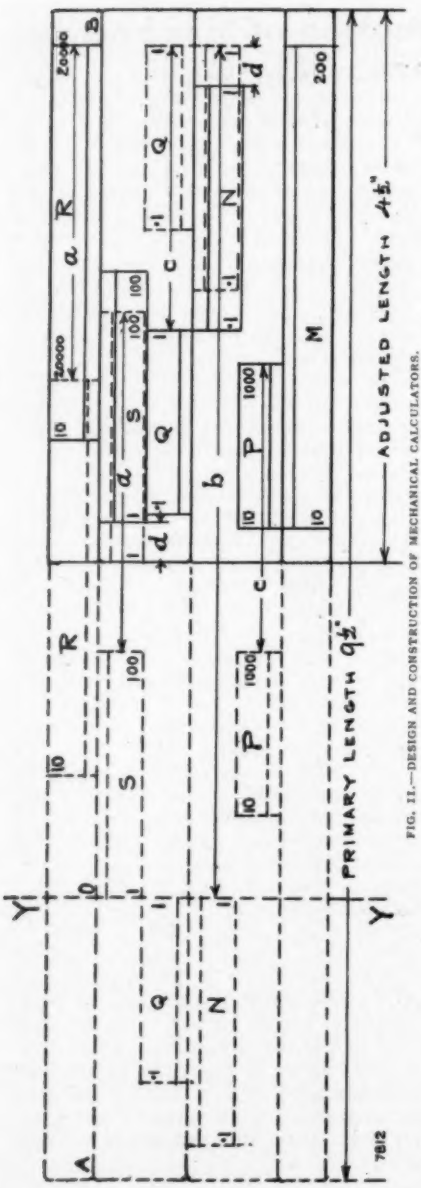

FIG. 11.—DESIGN AND CONSTRUCTION OF MECHANICAL CALCULATORS.

Now let the same process be repeated with the other two scale lines, and the result will be the formation of two movable scale rings, outside and concentric with the fixed disk. Instead of these rings, however, two movable disks may be substituted beneath the fixed one, the under-lap of each disk giving a scale-width equivalent to the scale-ring. With this modification there will be two distinct scale circles on each movable disk, the outer one, forming the circumference of the disk, corresponding to the lower edge, and the inner one, the same diameter as the next disk above, corresponding to the upper edge of the equivalent slide. On this instrument, therefore, direct numerator and inverted denominator scales require to be placed on the inner scale circles, while direct denominator, and inverted numerator scales require to be placed on the outer circles or circumferences of the disks.

In the case of the straight slide instrument (Fig. 9) the fixed R and H scale lines are unlimited in length on each side of $Y\ Y$, but in this one they are finite. The first step, therefore, in the process of scale location is the determination of the diameter of the inner fixed disk circle. It was pointed out, in connection with Fig. 3, that a correction must be made to allow for variation of the base scale unit at each disk circle, and hence, in Fig. 12, all scales must first be laid off round the circumference of the fixed disk, and then projected radially on to the proper circles. It will therefore be evident that the circumference of this disk circle is determined by the greatest scale length of the set, for when projected to any other disk circle this length will occupy the same proportion of its circumference. The base scale unit being chosen to admit of the desired accuracy of reading on the scale of smallest dimensions, the circumference of the fixed disk can be chosen, so as to take the maximum scale length and allow a slight margin for clearance at the scale ends.

After the diameter of the fixed disk has been determined, the diameters of

the movable ones can then be chosen so as to allow a scale width of from $\frac{3}{4}$ in. to $\frac{7}{8}$ in. These dimensions having been determined, the process of setting out the primary arrangement on the circles from Y Y can, if desired, be gone through as indicated in Fig. 12, and the scales can then be adjusted in accordance with the rules deduced for the straight slide instrument; but by far the easier and simpler method is first to set out and adjust the straight slide arrangement as in Fig. 11, so as to obtain the necessary coincident scale values on each pair of traversing scales, and then, in accordance with rule IV. to transfer the pairs of full sized scale-lengths, in turn, direct to the fixed disk circle and project these on to their respective scale circles.

In order to illustrate the consecutive steps in the design of this form of calculator take again the general expression used in connection with the straight slide instrument, $R = \frac{M^3 N^2 S}{P^1 Q^2}$, the same ranges of values of the variables being

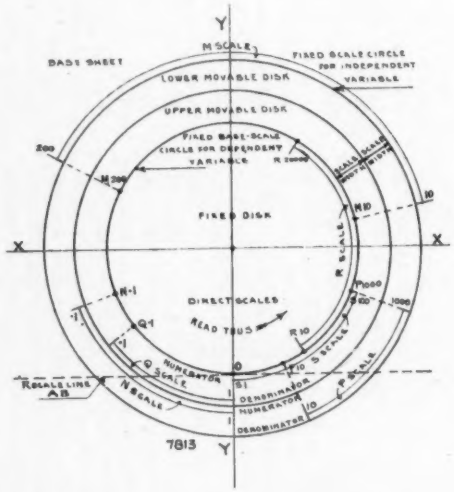

FIG. 12.

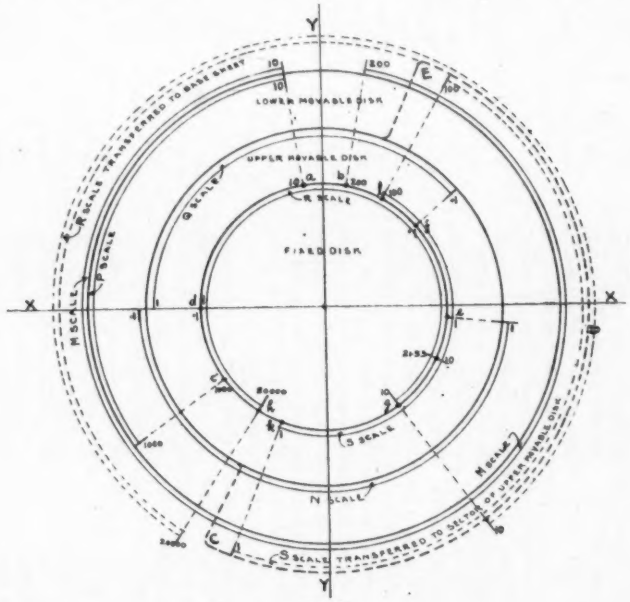

FIG. 13.

chosen. As already seen the longest scale length is that of the M scale, and equal to about $9\frac{5}{8}$ in., when the base scale unit is taken as half the unit length of the upper or "A" scale of a 10-in. slide rule. Allowing say $\frac{5}{8}$ in. clearance at the ends, the circumference of the fixed disk may be taken as $10\frac{1}{4}$ in. and the diameter $3\frac{1}{4}$ in. Allowing a scale width of $\frac{3}{4}$ in. the diameters of the movable disks will be $4\frac{3}{4}$ in. and $6\frac{1}{4}$ in. The scale transference to the circular scale lines on this instrument is certainly more troublesome than that of the straight-slide one, and requires the exercise of a good deal of care, in order to ensure accurate spacing; but it will be found that the result is worth the extra trouble involved. As a preliminary step, set each scale length out on the edge of a stiff cardboard strip or the back edge of an ordinary paper drawing scale. Draw the $6\frac{1}{4}$-in. fixed circle with vertical and horizontal diameters $Y\ Y$ and $X\ X$ on the base sheet, then cut the three disks out of two-sheet bristol board, drawing diametral lines at right angles on each disk, for guidance in setting. Centre the three disks on the base sheet by means of a stout needle, then fix them temporarily, with the diametral lines coincident, by means of another needle near the circumference of the upper or fixed disk. Begin with the outer fixed scale M. Bend the paper strip round the lower portion of the circumference of the fixed disk between a and b (Fig. 13) holding it in position round this, by one or two paper weights placed against it, then tick the principal M scale-divisions on to the circumference of the fixed disk between 10 and 200. Remove the paper-strip and project the scale divisions on to the outer fixed circle on the base sheet. Next rub out the scale marks on the fixed disk, with the exception of the $M = 10$ value at a, bend the P scale paper-strip round the disk, with $P = 10$ coincident with $M = 10$ at a, and mark the P scale divisions on the disk between a and c. Then remove the paper-strip and project the P scale on to the circumference the lower movable disk between 10 and 1000. Repeat the above process for the N and Q scales, placing the $N = \cdot1$ and $Q = 1$ values in coincidence at say d, marking the values between d and e and d and f and projecting the N scale between $\cdot1$ and 1 to the inner circle of the lower movable disk and the Q scale between 1 and $\cdot1$ to the circumference of the upper movable one. Finally, bend the paper-strip with the base scale, round the fixed disk between g and h and mark the R values between 10 and 20,000 permanently. Then adjust the strip until $S = 10$ coincides with $R = 21{\cdot}53$ and mark the limits of the S scale between k and l, on the inner circle of the upper movable disk. The upper movable disk can then be turned until k is coincident with $R = 10$ at g and the S scale can then be transferred from the R scale, as both these scales are of the same dimensions.

It should be noted here that the points of coincidence, a, d, g, &c., can be located anywhere on the fixed disk circle, so as to give a symmetrically disposed arrangement of scales on the movable disks and base sheet. If for any reason it is found desirable to alter the disposition of the skeleton scales, such as shown in Fig. 13, the mechanical rules of adjustment derived for the straight slide instrument can, as already mentioned, be employed to effect this.

This first form of the circular instrument, dealt with so far for the purpose of showing the process of evolution from the straight slide one, is not the simplest and most practicable one that can be constructed. The second form, derived from this one, by a simple modification of it, is to be preferred for several reasons.

It will be noted here that the employment of the fixed disk necessitates four scale transpositions and projections. Now, suppose that instead of retaining the R scale on the circumference of the fixed disk, it is expanded radially on to a second fixed circle, on the base sheet, and that the upper movable disk carrying the S scale on its inner circle is provided with a projecting sector having its arc $C\ D\ E$ the same radius as this new fixed R circle. Then if the S scale is

also radially expanded to the arc of this sector, it will be evident that for any given displacement of the two movable disks, the final reading on the inner R scale against any value of S will be the same as the reading against the same value of S on the outer R scale. The simplification can, however, be carried further, if the common radius of the R and S scale-circles is made the same as that of the outer fixed or M scale circle. When this is done, it will be apparent that the M and P scales can be transferred *directly* to the outer scale circle and circumference of the lower movable disk, and the scale projections are thereby reduced from four to two. In this improved form of the circular design, it should, however, be borne in mind that the upper disk circles are overlapped, and that the circumference of the projecting sector, viz., the arc $C\ D\ E$, is equivalent to the inner scale-circle of the disk. From the above considerations it further follows that, where only one movable disk is necessary, its circumference represents both its inner and outer scale-circles. Since the single fixed circle on the base sheet now constitutes the common scale-circle of the independent and dependent variables M and R, its circumference is fixed by the sum of the M and R scale lengths, plus the necessary clearance between the scale ends. Retaining the same base scale unit, the R scale length between 10 and 20,000 is about $8\frac{1}{2}$ in., and as the M scale length is about $9\frac{5}{8}$ in., the net circumference of the fixed circle is about $17\frac{3}{4}$ in. Increasing this to $18\frac{3}{4}$ in. to allow about $\frac{1}{2}$ in. clearance between the scales, the diameter of the fixed circle becomes 6 in. Allowing as before a $\frac{3}{4}$ in. scale width, the diameters of the disk are 6 in., and $4\frac{1}{2}$ in. for the smaller part of the upper disk. Begin with the M and R scales, marking the M scale on the lower, and the R scale on the upper portion of the fixed scale circle. To do this in the most expeditious manner, cut a service disk of thick cardboard, whose radius is less than that of the fixed scale circle by an amount equal to the thickness of the cardboard scale strip. Centre and fix this disk on the base sheet, and when the scale strip is bent round it, its outer side will coincide exactly with the fixed circle. The scales can then be transferred to the base sheet.

Next place the lower movable disk in position; centre and fix it to the base sheet, and bend the Q scale strip round its circumference, so that the Q scale is symmetrically disposed about the vertical diameter on the lower portion of the circumference; then transfer the scale divisions to the disk. Before proceeding further, ascertain the necessary length of the arc of the sector of the upper disk to take the S scale length, and cut the upper disk with this portion 6 in. diameter and the rest $4\frac{1}{2}$ in. diameter. Place the upper disk in position, and project the Q scale from the lower disk circumference to the circumference of the smaller portion of the upper disk (which, it must be remembered, is really the outer scale-circle of this disk). Next rub out the Q scale divisions on the lower disk, except the $Q = 1$ value, bend the N scale strip round the disk with $N = \cdot 1$ coincident with $Q = 1$; transfer the N scale and project it on to the inner circle of the lower disk. Finally mark off the S scale from the R scale.

With reference to the transposition of the complete scales on the disk instrument, the correctness of the main scale divisions should be tested before the subdivisions are lined in and projected. For this purpose service disks of stout tracing paper may be employed. A cardboard centre should be pasted on each disk to prevent the hole from being enlarged by the centre needle. The scales can be retraced on the disks, and trial multiplications and divisions can be made to check the accuracy of the spacing. Service disks of bristol board may also be used. When any scale length consists of more than one unit length and subdivisions, the test or service disk simplifies the work of scale transference considerably. The unit length of the scale having been drawn on the test disk it can be retransferred

to the coincident fixed scale circle or disk circle, as many times as are necessary to obtain the complete scale length.

Contrasting this second and more practicable form of the disk instrument with the straight slide one, as far as scale transposition is concerned, its construction entails more work than that of the other, but in the matter of size it has a slight advantage. The scale lengths in both instruments are the same. The diameter of the fixed scale circle is 6 ins., as against the net scale length of 9⅝ ins. of the straight slide instrument. A further reduction would result were the lengths of the fixed scales less nearly equal. It may, of course, be quite reasonably argued that any advantage in length is counterbalanced by the increased breadth of the disk instrument. There is, however, a decided operative advantage which is not rendered apparent by the diagrams. Anyone who takes the trouble to handle in succession, a straight-slide single or compound instrument, and the equivalent disk, one will probably discover that the cardboard disks, which require only the light touch of the fingers to move or hold them in position, can be much more easily and rapidly adjusted and fixed than the too often stiff or jerky slides of the rule. The latter require to be pushed or pulled with more or less force, and have, with the ordinary design of compound instrument, a perverse tendency to slide together when only one slide is to be moved. Again, from the constructional standpoint, it will be seen later that the disk instrument has a further advantage over the straight slide one.

Although the principles of the scale adjustment, &c., for the disk instrument are essentially the same as those for the straight slide one, it is advisable to restate the rules of design in a form more suited to this altered combination.

Rules of Design for Disk Calculators.—Given any factorial expression involving n variable elements, which is to be embodied in a scalar calculator of the disk type, then :—

I. The instrument, to ensure a continuous mechanical solution, must be provided with $\frac{(n-2)}{2}$ movable discs when n is even, and $\left\{\frac{(n-2)}{2}+\frac{1}{2}\right\}$ when n is odd.

II. Direct numerator and inverted denominator scales are placed on the inner, and direct denominator and inverted numerator scales are placed on the outer circles of the movable disks. When the scales of the dependent and independent variables are placed on the same fixed scale circle, the foregoing statement is reversed in the case of the upper and overlapping disk.

Direct scales are those which read round the circles in the same direction as the fixed base scale or scale of the dependent variable.

III. The unit length of each factor scale must be made equal to (base scale unit × exponent of the power of the factor).

IV. Any pair of traversing scales, either a fixed scale and a scale on an adjacent disk, or two scales on adjacent disks, may be shifted through the same angle, in the same direction, without affecting the positions of the other scales.

V. An outer circle scale may be shifted, provided that either the inner circle scale on the same disk is shifted through the same angle in the same direction, or the outer circle scale on the adjacent disk is shifted through the same angle in the opposite direction.

VI. When an absolute constant occurs as a numerator co-efficient, either a direct numerator or inner circle scale must get a positive shift, or an inverted numerator or outer circle scale must get a negative shift, through an angle subtended at the base scale circle by the log. value of the constant. Conversely, a direct denominator or outer circle scale must get a negative, and an inverted denominator or inner circle scale a positive shift. When the constant occurs as a denominator co-efficient the above order of adjustment is reversed.

The Design of Engineering Workshops—V.

By H. MUNCASTER, A.M.I.Mech.E.

(Previous Articles appeared in Vol. XIV., pp. 24, 86, 187, 268.)

Girders.—In the preceding examples given of shops, a variety of purposes were indicated for which girders are used, such as the carrying of gantry cranes, the supporting of roof principals, galleries, &c.

These girders are in some instances constructed of rolled steel H sections bolted to brackets on the stanchions, and fish-plated at the joints.

In Fig. XI. was shown a cross section of a machine shop where girders of rolled H section are used for all these purposes, the strength of the bar being in each case sufficient, without the necessity of additional plates or bar being riveted thereto.

Figs. 19 and 20 give details of a sample of girder work for a gallery. All the steel work is of rolled sections. The gallery is 170 ft. in length by 20 ft. wide, carried on six columns. A line of 16 ins. by 6 ins. rolled girders extend from column to column, the full length of the shop. At each column there is a girder of similar section running at right angles, of which one end is supported by the column and the other end built into the wall. The flooring joists are carried on these girders and on intermediate girders supported by the longitudinals. The attachments are in each case made by means of angle cleats bolted or riveted to the webs of the various members. The girders are of different levels, the idea being to save the notching of the joists. On each joist a wooden sleeper $4\frac{1}{2}$ ins. by 3 ins. is fixed by means of coach-screws through holes in the top flanges, arranged zigzag about 3 ft. apart. To these sleepers are nailed 3 ins. flooring boards.

With regard to the use of bolts for fastenings, where rolled joints and other similar sections are to be connected there are some practical considerations that should be taken into account. In designing these joints each bolt is assumed to take its share of the load, the safe load on each bolt being divided into the total load to get the number of bolts required. If the holes were absolutely true and all the bolts of the same diameter, the result would be quite satisfactory, and even a slight divergence might, on account of the elasticity of the material, be allowed without the risk of failure. Many examples that have come under the writer's notice, however, have been very unsatisfactory on account of the holes being out of line, and the bolts only got in place after the use of a drift. It is usual to allow about $\frac{1}{16}$ in. larger diameter in the hole than in the bolt. If all the bolts, assuming there are six or eight, will go in without the aid of a drift, it is considered to be a fairly good job. The possibilities are, however, that in most cases the whole load is taken by one or two bolts, especially when the holes are punched. If rivets are to be used, the holes may to some extent be filled up by hammering when closing the rivets, thus ensuring a better distribution of the load, but in case it is decided to use bolts great care should be taken to ensure that the bolt holes register true. To get at this, it is a good policy to use the actual pieces as a template, and with a scriber carefully mark the holes, and drill to suit. Punching the holes may be permitted where the bolts are simply in tension, but where the bolts are to take a shearing strain, it is certainly preferable to have the holes drilled.

Previous examples show rolled H

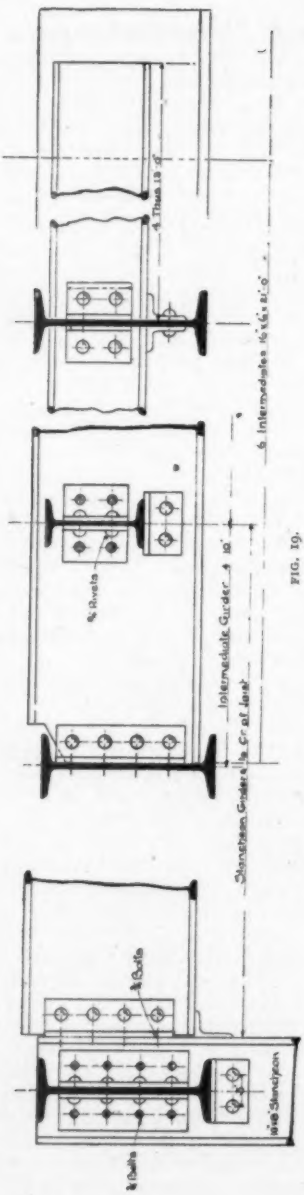
Intermediate Girder
Abutment Girder
Rivets
Rivets
Rivets

FIG. 19.

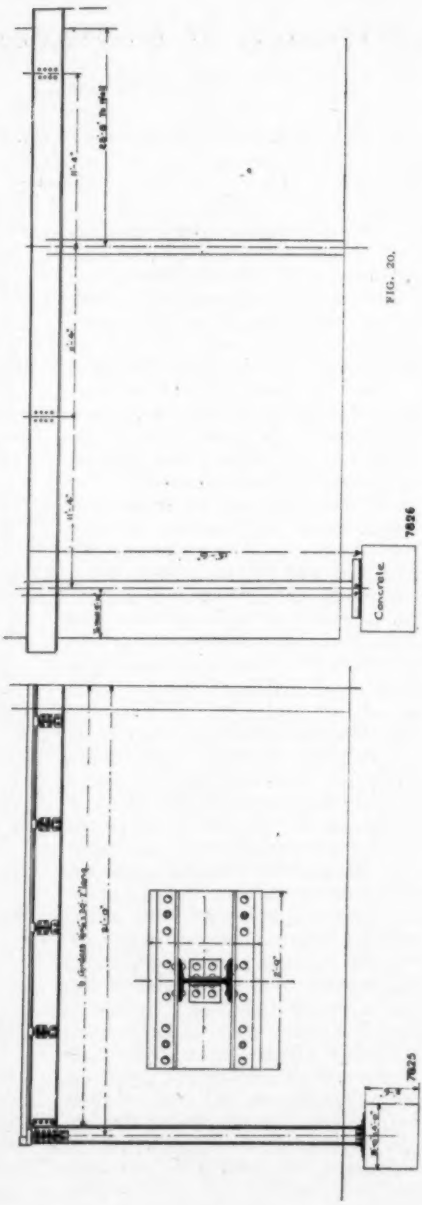
Concrete
7826
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FIG. 20.

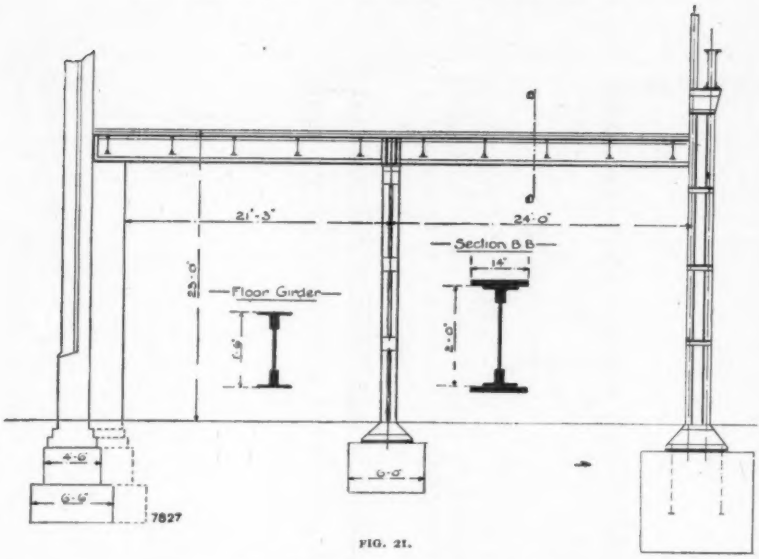


FIG. 21.

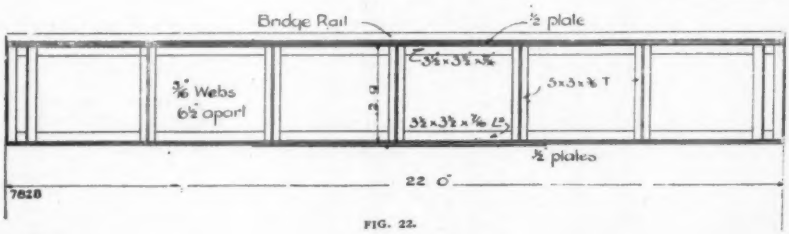


FIG. 22.

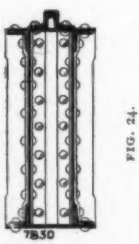


FIG. 24.

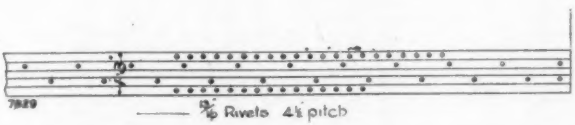


FIG. 23.

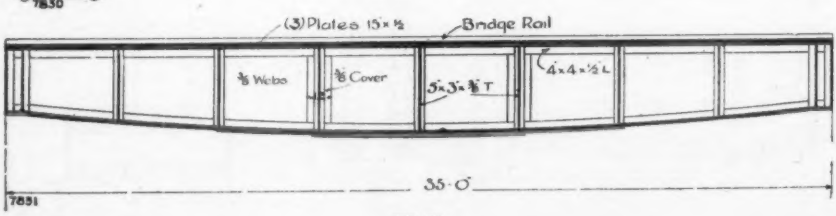


FIG. 25.

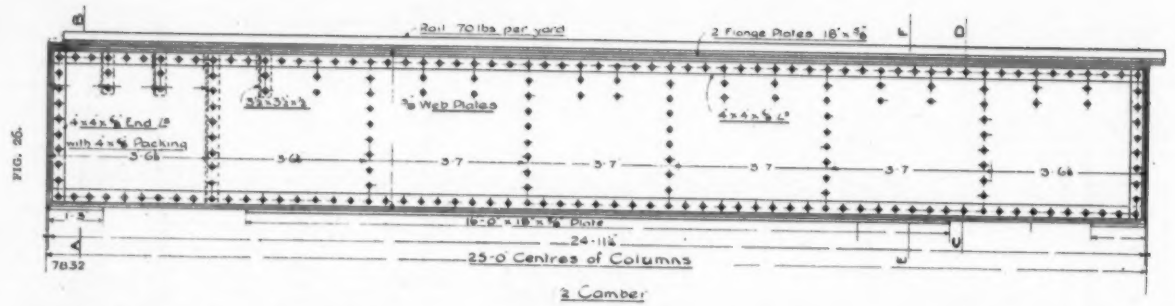


FIG. 26.

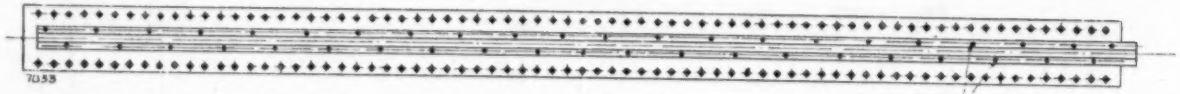
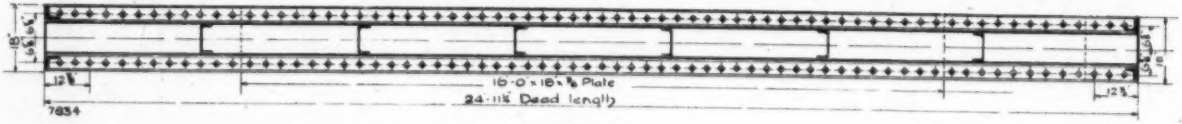


FIG. 27.

Rivets in Rail



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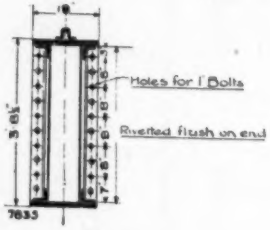
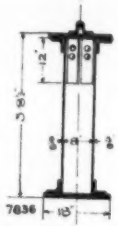


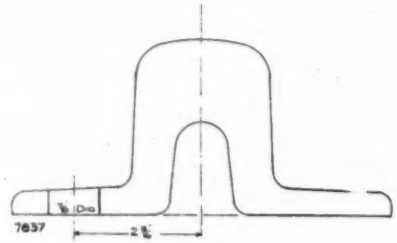
Section A B

FIG. 29.



Section E F

FIG. 30.



Section of Rail 70 lbs per yard

FIG. 31.

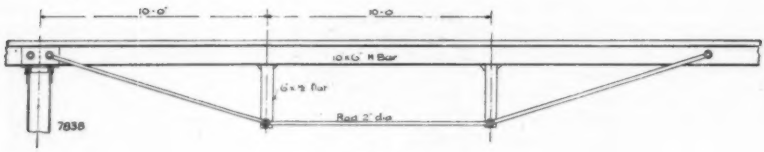


FIG. 32.

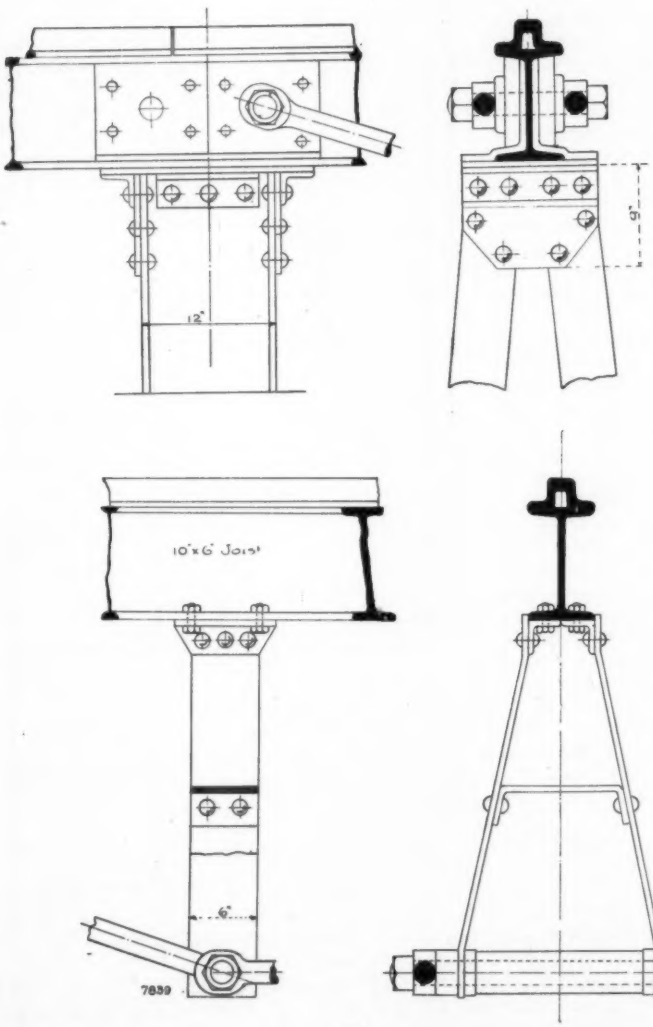


FIG. 33.

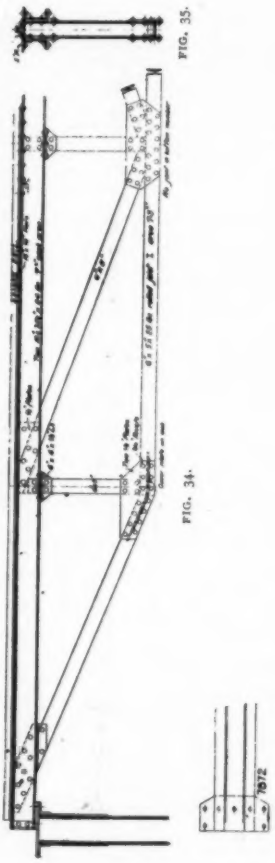
section girders for gantry cranes. These are generally connected by a fish-plate at each side of the web across the joint.

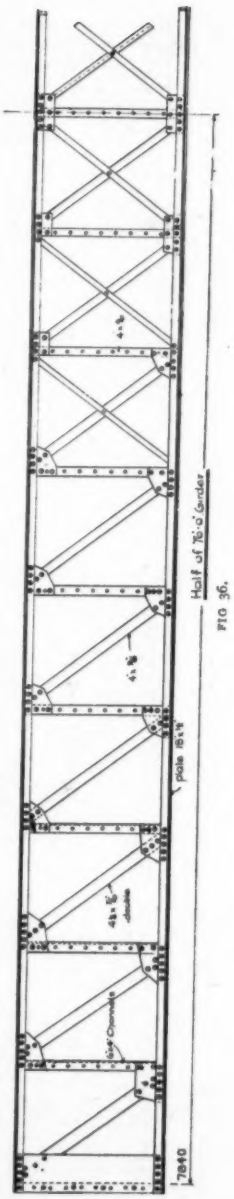
Fig. 21 gives three views of a floor entirely built up of plates and angles. This is intended to carry a load of 3 cwt. per square foot, with an allowance for strains incidental to the moving of heavy machine parts, &c., under construction. The main girders are 25 in. deep. The top and bottom plates are 14 ins. wide by $\frac{1}{2}$ in. thick, supplemented by an extra plate in the middle of about 12 ft. long. The web is $\frac{7}{16}$ in. throughout. The joists are 18 in. deep, with two 4 in. by 3 in. by $\frac{7}{16}$ in. angles top and bottom. The web is $\frac{3}{8}$ in. thick. The floor is made of $2\frac{1}{2}$-in. boards, laid across sleepers attached to the joists. Over the boards are laid diagonally a second set of boards of about 1 in. in thickness. The upper boards are a provision for wear, as these can be renewed at any time without damage to the main floor.

Figs. 22 and 23 show the side view and plan, and Fig. 24 the cross section of a gantry girder designed to carry a 45-ton traveller over a span of 22 ft., between centres of columns. As will be seen, the web is double. The plates are $\frac{5}{16}$ in. thick, and they are placed about $6\frac{1}{2}$ in. apart. The depth of the girder is 45 in., and the top and bottom plates are $\frac{1}{2}$ in. thick. The webs are stiffened by 5 in. by 3 in. by $\frac{3}{8}$ in. Tees, about 4 ft. 3 in. apart.

Fig. 25 shows a girder for a similar load where the columns are 35 ft. apart. The extra strength is arranged for by making the girder deeper in the centre, after the usual fish-belly pattern, and by the addition of an extra plate on the flanges.

Figs. 26 and 27 show side view and a plan of a girder suitable for carrying a 100-ton traveller over a 25 ft. span, centre to centre, of columns. This girder is of the double-web type, built on similar lines to the above. There are six vertical stiffeners made out of 8-in. by $3\frac{1}{2}$-in. channels fixed





between the two webs, and extending from the top to the bottom. There are also fourteen intermediate stiffeners o 12 in. in length, shown in the horizontal section (Fig. 28). These have a stiff angle riveted to the upper end which supports the top plate (see Fig. 30), the object being to distribute the load carried on the rail.

Occasionally a girder is made of a rolled H section bar, trussed when the span is comparatively long and the load moderate. Three examples are given, the first of which (shown in Figs. 32 and 33) is braced by a couple of round rods connected to flat iron struts. The rods have a considerable spread under the middle of the girder. This is done with a view of preventing any sideways vibration. The second example (Figs. 34 and 35) is of a 40 ft. span gantry girder. This is made of a double channel top boom, with bracings of H section rolled steel bars. The connections at the joints are made of flat plate, to which the bars are riveted.

The third example (Fig. 36) is of a girder supporting the ends of roof trusses over a space of 76 ft. It will be noticed that all the diagonals are of flat iron, this only enabling them to be of service when in tension. As these diagonals are, however, carried some three bays beyond the centre of the girder, it is assumed that this will provide for any strains due to unequal loading, on account of wind or other incidental causes. As explained by the notes on the sketches the bracing is double, the angles on the booms being $6\frac{3}{4}$ ins. apart. No great amount of stiffness sideways is needed, as the roof principals are bolted to the girder, and will prevent any swaying, the principals themselves being tied up by diagonal wind bracing.

(To be continued.)

Historic Locomotives of the West of Flanders Railway.

By ALFRED R. BENNETT, M.I.E.E.

THE transfer next year of the West Flanders Railway to the Belgian Government will put an end to a notable British enterprise. In the early days of railways the Belgian Government were not inclined to lavish expenditure on railway exploitation, and it came about in consequence that concessions were granted to a good many British companies who were not averse from risking their capital in developing the country. Most of these have gradually been absorbed by the State. But the West of Flanders Company, which, in 1845, was granted a concession to construct a railway from Bruges to Poperinghe, *via* Courtrai and Ypres, is still independent. In 1864, power was obtained to extend from Poperinghe to the French frontier, whence, under a concession from the French Government, a connection 15 kilometres long was made with the Northern Railway of France at Hazebrouck, in French Flanders, the West Flanders Company being given the use of the station there in consideration of a yearly payment of 80,000 francs to the Northern Company. In 1887 a 90 years' concession was obtained for an extension from Roulers to Menin, in the direction of Lille. Fig. 1 is a plan of the West Flanders Railways as they exist to-day. They comprise a route length of 182 kilometres, or 113 English miles, practically all single line, except in the vicinity of the stations. Of late years the Belgian Government have repented the grant of such long concessions, and as they wish to establish a first-class connection between France, *via* Lille, and the great watering-places of Ostend, Blankenberghe and Heyst (see Fig. 1) they determined if possible to acquire the West Flanders line, which lay directly in the contemplated route, without waiting for the concessions to fall in, and by doubling the track from Menin to Bruges to provide a main line for direct express trains between Lille and the Belgian coast. Through carriages from and to the watering-places are already run over the West Flanders line, and a few of the West Flanders trains work through to Heyst *via* Blankenberghe over the State Railways, but these facilities are

FIG. 1.

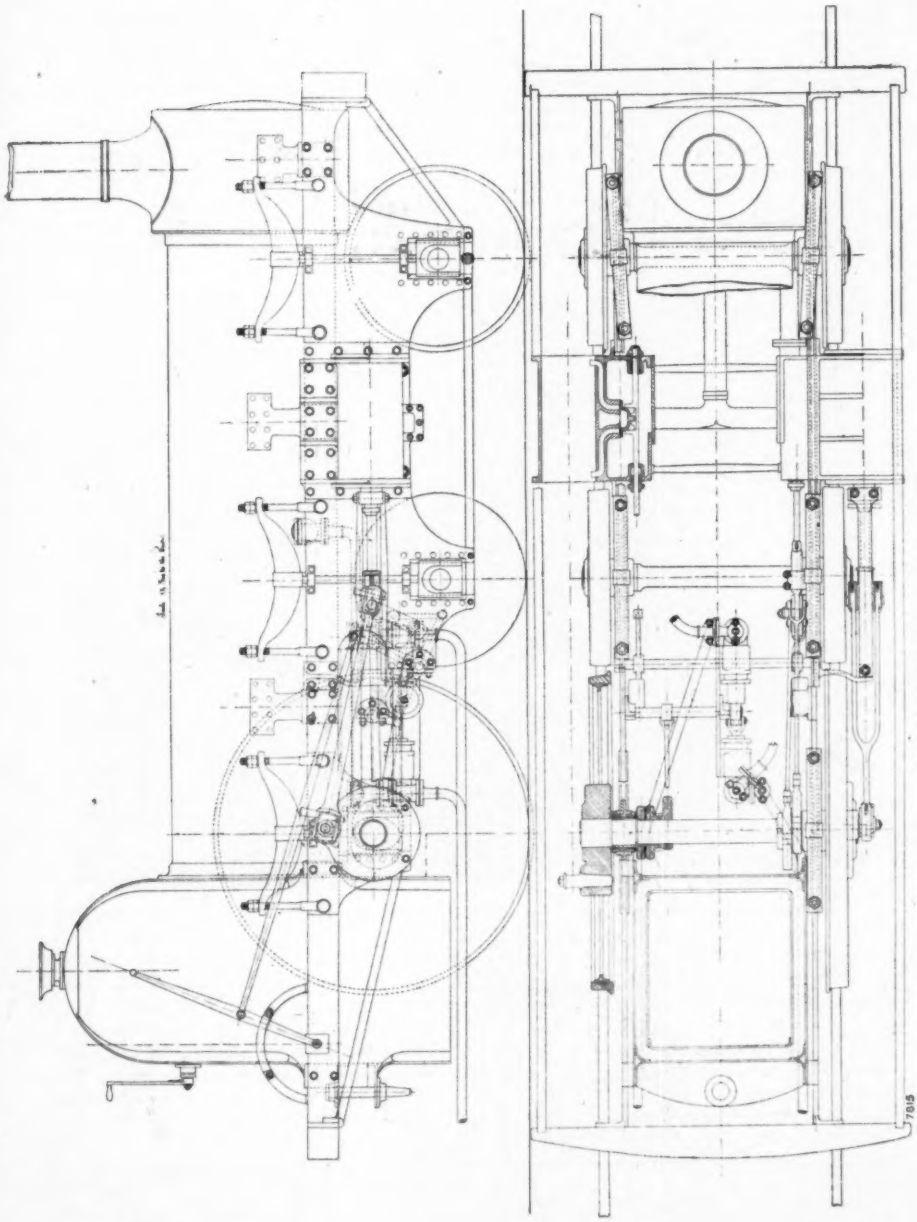


FIG. 2.—"STEPHENSON" LONG BOILER ENGINE.

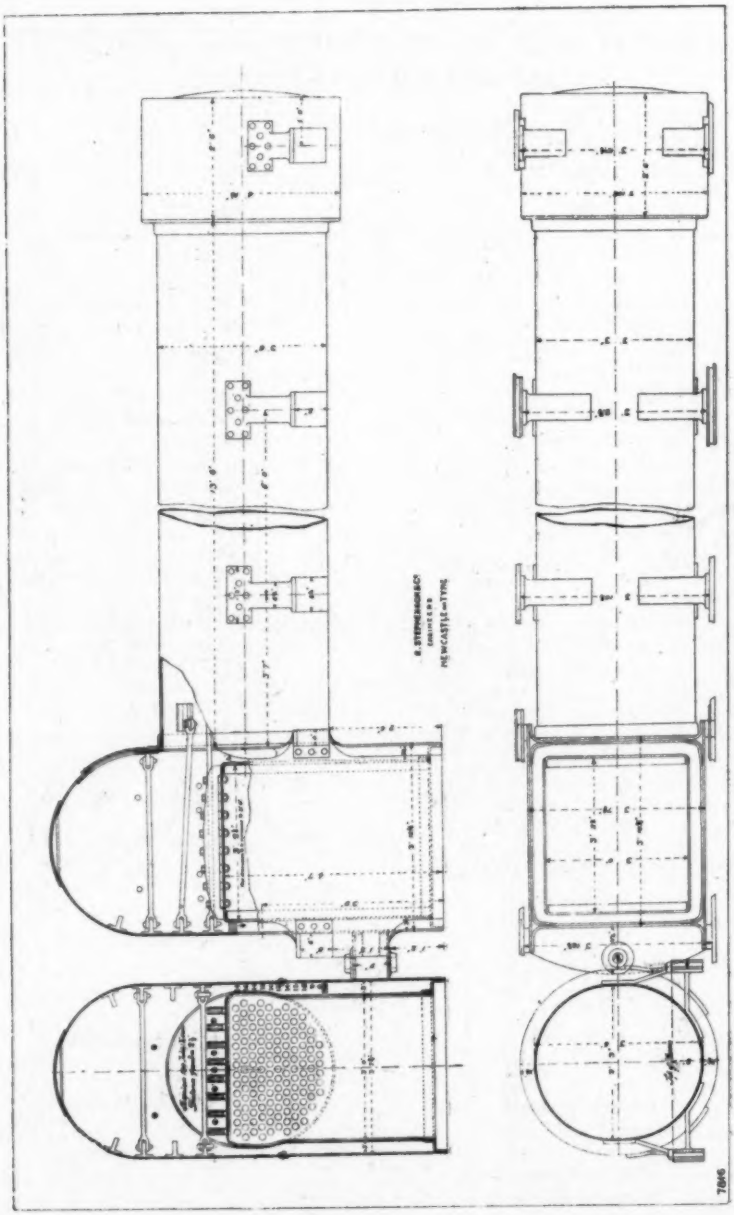


FIG. 3.—"STEPHENSON" LONG BOILER ENGINE.

not accounted sufficient. Negotiations were prolonged, the Company naturally wishing to make the best of the strong position afforded it by its unlapsed concessions; but eventually, in May last, an agreement exceedingly satisfactory to the shareholders was arrived at, whereby the West Flanders Railway will become the property of the Government as from January 1st, 1906, subject to Parliamentary sanction being obtained; but as the State will not enter into actual possession until two months after the arrangements have been approved by Parliament, the actual working remains in the hands of the Company until some date in 1907 not yet definitely fixed.

The West Flanders Railway comprises no notable engineering works, the country traversed being as a rule flat, and the natural obstacles insignificant. From an engineering point of view the line is only interesting by reason of its early locomotives, dating from 1846 to 1863, all of which, with one exception, are still working.

The first section of the line from Bruges to Roulers, opened on October 5th, 1846, was worked by four Stephenson's long-boiler engines. Four more were added in the following year. The original ones were built at Stephenson's Newcastle Works from working drawings, dated November 5th, 1845,

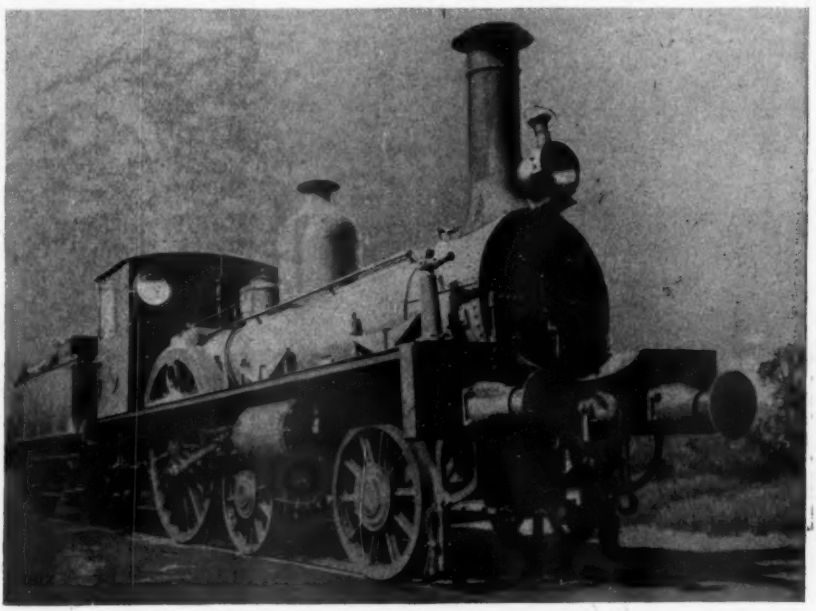


FIG. 4.—"STEPHENSON" LONG-BOILER ENGINE, WITH RECONSTRUCTED BOILER AND BELPAIRE FIREBOX.

and initialled by Robert Stephenson, copies of which, by the courtesy of M. de Lannoy, General Manager, and M. Albert Fraeijs, Chief Engineer of the Company, we are enabled to give in Figs. 2 and 3. This is probably the first time that detailed drawings of this celebrated type have ever been published. As originally supplied the engines had haycock boilers, but about 1863 these began to be renewed by boilers with Belpaire fire-boxes, which were found more efficient for

burning the inferior Belgian coal. The second lot of four were constructed by the Société St. Leonard, Liège, and were exact copies of Stephenson's. With the reconstructed boilers seven of the original eight engines are still at work, fitted with the Westinghouse brake, and running passenger trains daily, chiefly between Ypres and Roulers, Ingelmunster and Courtria, and Ingelmunster and Thielt. A photograph of engine No. 2, which commenced to work in October, 1846, is shown in Fig. 4, while No. 7, one of the second lot, which dates from 1847, and which was originally known as "La Belle Flamande," is shown in Fig. 5. It is probably fully thirty years since the last engine of this type was seen running in Great Britain, and the existence of these long-boiler engines still in daily use so close to the British shores is unquestionably interesting. At one time this type of engine was largely employed in the express service of the southern division of the London and North-Western Railway, but was not much used after the amalgamation of the northern and southern divisions in 1862. Many of the other British railways owned engines of this class, but they were reputed to run very unsteadily, and in many cases a fourth pair of wheels was added behind the driving wheels. But at the speeds at which they are required to travel in Belgium no particular unsteadiness is noticeable. Only one of these engines, No. 1, has been scrapped, and the remaining seven will be handed over next year to the Belgian States Railways on the transfer of the line.

The dimensions of these engines are:—

Cylinders, 15 ins. by 24 ins.
Driving wheels, 6 ft. 6 in. diameter.
Heating surface: firebox, 11·47 sq. ft.
" " tubes — number, 139; surface, 850·93 sq. ft.
" " Total, 862·4 sq. ft.

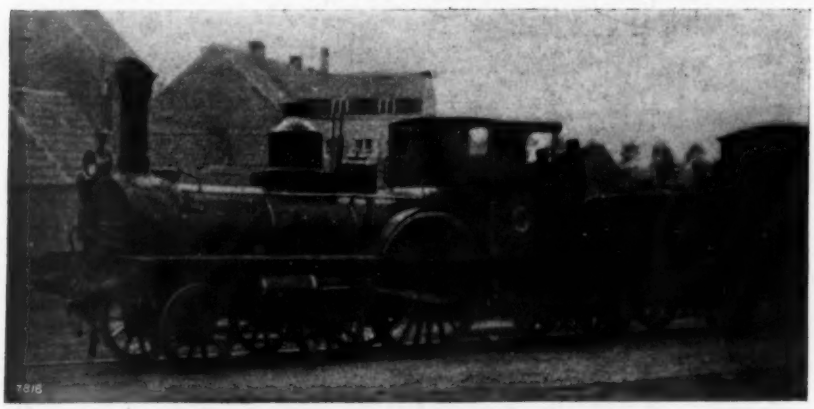


FIG. 5.—COPY OF "STEPHENSON" LONG-BOILER ENGINE BUILT AT LIÈGE.

Length between tube plates, 14 ft. 2⅜ ins.
Thickness of boiler shell, ½ in.
Working pressure, 120 lbs., the boiler being proved up to 180 lbs. with cold water.
Weight, empty, 16 tons 1½ cwt.

These eight engines served all purposes up to 1853, when the increase of train loads led to coupled engines being called for for the goods trains, and in 1853 a six-wheeled, four-coupled engine was ordered from Messrs. Wilson & Co., of the Railway Foundry, Leeds, of which a photograph in her present condition is given in Fig. 6. Beyond the addition of a cab, a sandbox on the boiler, and the substitution of injectors for the

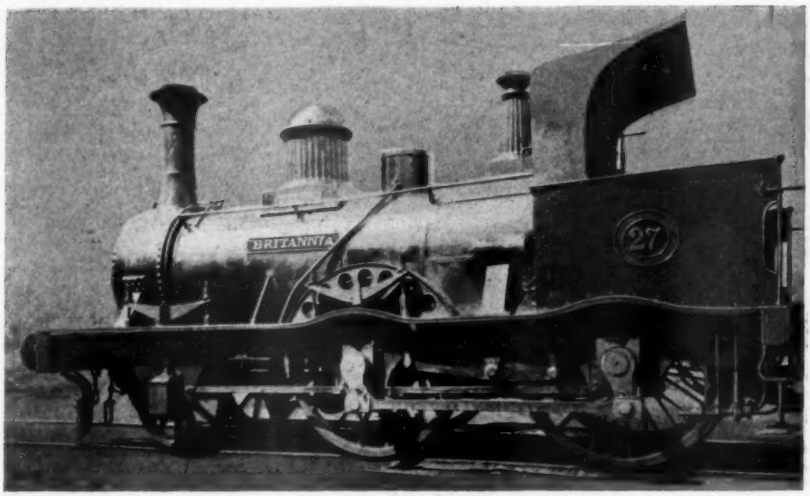


FIG. 6.—A SURVIVAL OF THE CELEBRATED "JENNY LIND" CLASS. FOUR COUPLED ENGINE BUILT BY MESSRS WILSON & CO., LEEDS

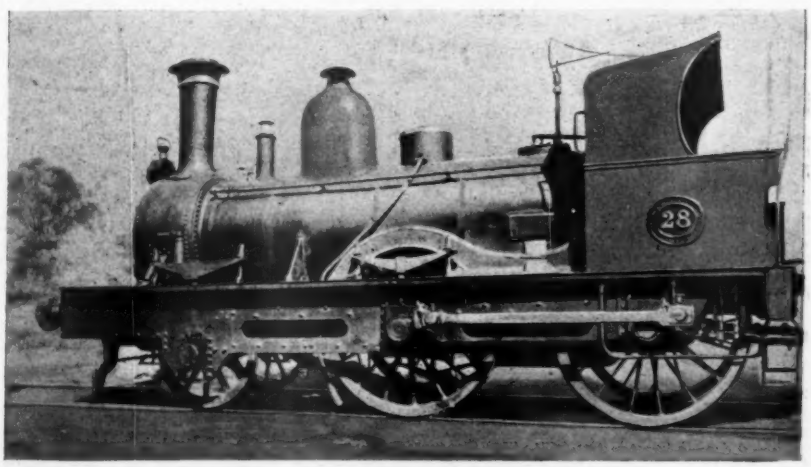


FIG. 7.—SIMILAR ENGINE TO THE ABOVE, CONSTRUCTED AT LIÈGE.

FIG. 8.—FOUR-COUPLED ENGINE BUILT BY MESSRS ENGLAND, SONS & CO.

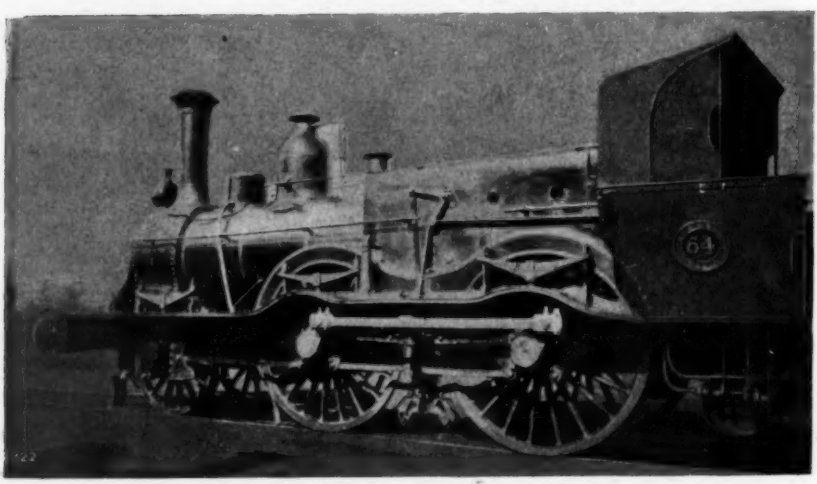


FIG 9.—SIMILAR ENGINE TO THE ABOVE, BUT REBOILERED.

original pumps, the engine is practically in its original condition, the boiler not having been renewed. When this engine came from Leeds, she bore the name of "Britannia" and was numbered No. 10, but the name plates were removed some years ago and the number altered to 27. The name plates were temporarily restored for the purpose of the present photograph, which was taken in August of this year.

whether a similar survival of the celebrated "Jenny Lind" variety could be discovered anywhere else. She gave such satisfaction that an order was almost immediately placed with the Société St. Leonard to construct two similar ones. These are now numbered 28 and 29, and began to work in 1854.

Fig. 7 shows No. 28 as photographed at Roulers in August, 1906. Her dimensions, as well as those of No. 29,

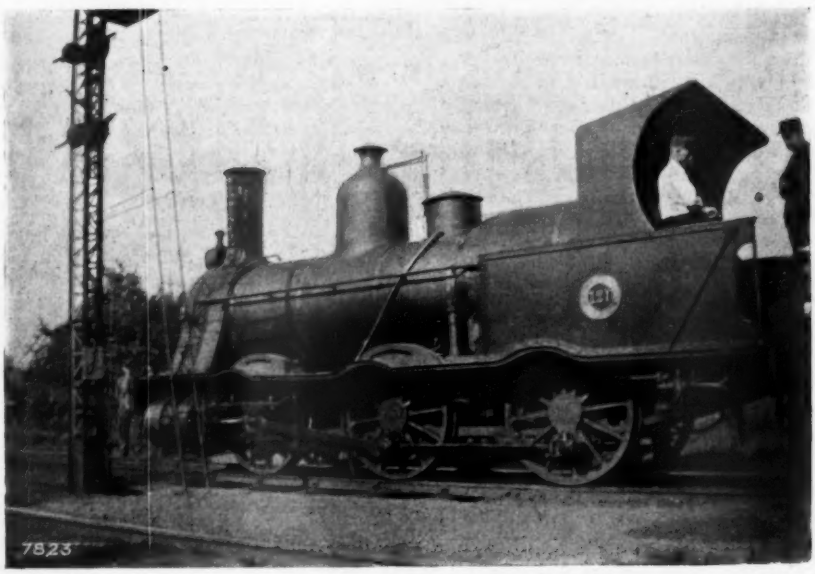


FIG. 10.—SIX-COUPLED OUTSIDE CYLINDER GOODS ENGINE.

The dimensions of this engine are as follows:—

Cylinders, 16 ins. by 22 ins.	
Coupled driving wheels, diameter	5 ft. 6 ins.
Heating surface: firebox,	68·64 sq. ft.
,, ,, tubes—number,	184, of 1¾ ins. diameter; surface, 856·49 sq. ft.
,, ,, Total,	925·44 sq. ft.
Length between tube plates,	10 ft. ½ in.
Thickness of boiler plate,	½ in.
Working pressure,	124 lbs.
Weight, empty,	20 tons 1 cwt. 37½ lbs.

No. 27 is especially interesting to British engineers, as it is questionable

are very similar to those of No. 27, the cylinders being 16 ins. by 22 ins., the coupled driving wheels 5 ft. 7 ins. in diameter, and the heating surface 953·33 sq. ft. Both have still the original boilers.

In 1863 the West Flanders Company took delivery of six six-wheeled four-coupled engines from Messrs. England, Sons & Co., of Hatcham Ironworks, London. England & Co. were the only private locomotive builders who ever existed in London, and their factory, now in the occupation of Eno's Fruit Salt Co., Ltd., still stands in Pomeroy

Street, Peckham, close to the Old Kent Road station on the South London Railway. These engines when delivered had the Cudworth double firebox, and were practically identical with the later four-coupled engines designed by Mr. Cudworth for the South-Eastern Railway, many of which were also built at the Hatcham Ironworks. But the double firebox was not found efficient for the Belgian slack coal, and the boilers were soon rebuilt with fireboxes of the Belpaire variety. Two or three of the engines have since been supplied with entirely new boilers, but the others, one of which is shown in Fig. 8, from a photograph taken this year, are still in the shape they assumed after the Belpaire alterations. Fig. 9 is a photograph of one of the same class of engine as reboilered. The dimensions are:—

Cylinders, 16 ins. by 24 ins.
Diameter of coupled driving wheels, 6 ft.
Heating surface: firebox, 94·9 sq. ft.
" " tubes—number, 195, of 1¾ ins. diameter; surface, 755·13 sq. ft.
" " Total, 850·04 sq. ft.
Length between tube plates, 10 ft. ⅛ in.
Working pressure, 120 lbs.
Weight, empty, 29¾ tons.

These engines still work the passenger service between Courtrai and Hazebrouck *vid* Ypres, and between Courtrai, Ingelmunster, and Roulers, besides taking their turns on other sections of the railway.

This finishes the tale of British engines, the rest of the Company's stock consisting entirely of Belgian manufacture. With the exception of two classes the balance of the locomotives resemble the types in use on the Belgian State Railways. The first of the exceptions is a class of seven six-wheeled outside-cylinder four-coupled passenger engines dating from 1863, and numbered between 30 and 41. They closely resemble engines in use on the North of France Railway, and were built at Tubize Works. The principal dimensions are:—

Cylinders, 16¾ ins. by 23¾ ins.
Driving wheels diameter, 5 ft. 10⅛ ins.
Heating surface, 1164·55 sq. ft.
Working pressure, 150 lbs.

The other special class consists of six outside-cylinder six-coupled goods engines, built at Tubize Works in 1868 and numbered between 105 and 121. They have cylinders 17¾ ins. by 25½ ins., driving wheels 4 ft. 10½ ins. in diameter, their heating surface is 1,373·07 sq. ft., and their weight in working order 34 tons.

These engines, which are represented by Fig. 10 are all working with the original boilers, and are great favourites, their performances both from a hauling and an economical point of view being highly satisfactory.

High Pressure Steam Tests of an Injector.

*By L. KNEASS.**

THERE are few devices connected with the operation of the locomotive that awaken so much interest, both from a practical as well as a theoretical point of view, as the injector. A knowledge of its action under conditions of steam pressure, height of lift and water supply temperature, is useful to the locomotive builder and railroad mechanical engineer, while the relation of its performance to the theoretical formulæ for delivery is of interest to the student of thermodynamics. It is, therefore, pertinent to present the results of a series of experiments covering an unusually wide range of conditions, and indicate diagrammatically the performance with locomotive boiler pressures, as well as the limitations of the injector in service.

The instrument that was tested is known as the improved self-acting injector, size No. 10½, and embodies certain features which render its study of value, and though the experiments are not exhaustive, yet they cover most of the practical applications; other features, which may be classed as minor, are omitted in this paper.

A sectional view of this injector in its simplest form is shown in Fig. 1. From the delivery tube *c* the other parts are proportioned, and the diameter is 10·5 mm. (0·41 in) at the smallest part of the bore. The main or forcing steam jet which forces the water into the boiler is 13·34 mm. (0·53 in.) in diameter, and the annular area of the lifting nozzle corresponds to a circular opening 8·13 mm. (0·32 in.). A special feature of the design is the continuous acceleration of the water between the suction branch and the smallest diameter of the delivery tube; the primary movement is given by the partial vacuum due to the condensation of the lifting steam jet a^1; the second, by the impulse of the steam discharge from this nozzle. The third increment is due to the low pressure within the condensing chamber of the forcing combining tube *bb*, and the final impulse, which adds sufficient velocity to the combined jet of water and condensed steam to pass through the contracted area of the delivery tube *c*, is due to the impinging of the steam from the forcing steam nozzle *a*. The resultant high velocity is then reduced to that of the water in the boiler feed pipe, by the parabolic divergent flare of

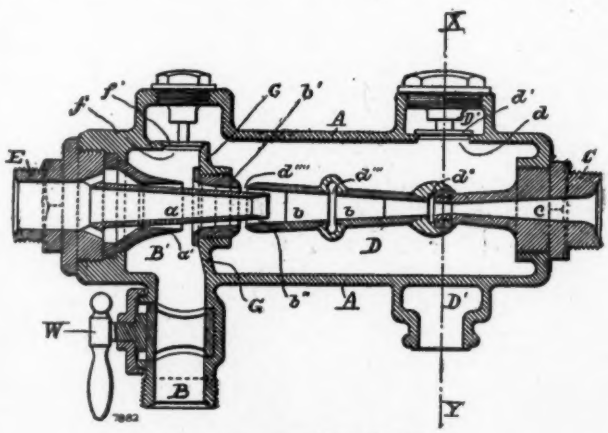


FIG. 1.—ELEMENTARY FORM OF INJECTOR.

* *Proceedings of the Franklin Institute.*

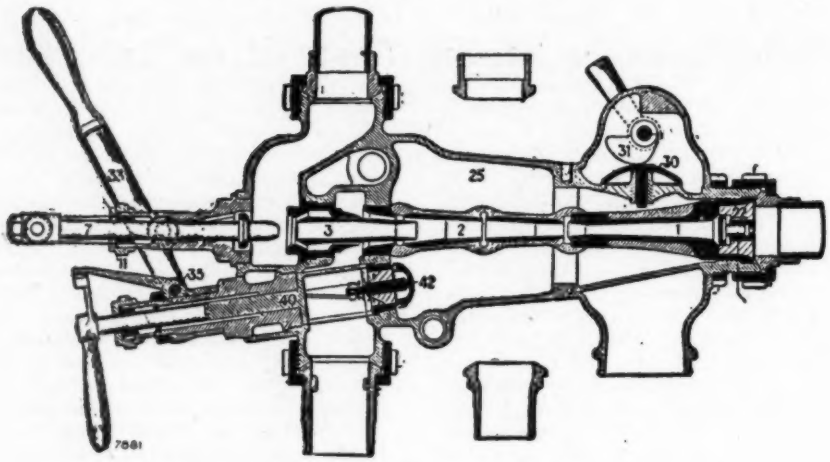


FIG. 2.—SERVICE FORM, LIFTING INJECTOR.

the delivery tube *c*, which is so proportioned that the negative acceleration or retardation shall be constant.

In this form of injector the two actuating steam jets are placed in the same axial line, so that the combining tube of the lifting steam nozzle discharges its supply of water directly into the receiving end of the forcing combining tube. Owing to the peculiar design and proportions of the nozzles, the capacity of either set of tubes is much less than that of the combined apparatus; this is due to the fact that when the two sets of tubes are working in conjunction, the pressure within the receiving end of the forcing combining tube is considerably below that of the atmosphere, and at times in 20 ins. vacuum, increasing the flow through the lifting tubes. These conditions obtain as the steam pressure rises until the increased discharge of steam from the forcing nozzle requires a greater supply of water than can be obtained from the lifting tubes, so that while the forcing jet is passing the apertures d^{11}, d^{111}, which open into the overflow chamber *D*, a partial vacuum is produced in the overflow chamber; some of the water in the suction pipe *B* and water chamber B^1 will therefore be diverted from the entrance of the lifting combining tube b^1, raise the supplemental inlet valve f^1 and enter the overflow chamber *D*, submerging the openings of the forcing combining tube. The jet in this tube will then draw the supplemental water supply from the overflow chamber *D* into the combining tube *bb*, and carry it through the delivery tube *c*, thus materially increasing the capacity of the injector.

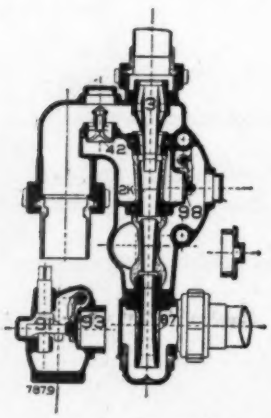


FIG. 3.—CLASS K, NON-LIFTING FORM.

At steam pressures below 120 lbs., the

capacity of the lifting set is sufficient to supply the forcing tubes and the supplemental inlet valve f^1 is inactive.

The apertures d^{11}, d^{111}, and d^{1111} in the forcing combining tube *bb* have a further function, namely, that of free discharge of steam from both nozzles without producing a back pressure in the suction chamber D^1; this permits the injector to restart automatically. Under all conditions of operation there is a partial vacuum in the suction pipe, for the overflow valve d^1 and its connecting outlet passage are of ample size to permit the free outflow of exhaust steam with all steam pressures.

The actual form of this injector, as used in service, is shown in Fig. 2, where No. 1 is the delivery tube, No. 2 the combining tube, and No. 3 the steam nozzle; No. 42 is the supplemental inlet valve, and No. 30 the overflow valve. The operation is as follows: Steam from the boiler is admitted to the lifting nozzle by drawing the starting lever No. 33 about 1 in., without withdrawing the plug on the end of the spindle (7) from the central orifice which admits steam to the forcing nozzle No. 3. The discharge of steam from the lifting nozzle exhausts the air and condensed steam or hot water from the suction pipe. When water appears at the overflow, the starting lever No. 33 is drawn back and the injector delivers into the boiler. At 200 lbs. steam pressure about 20 per cent. of the total water supply for the tubes is admitted through the supplemental inlet valve No. 42.

The water-regulating valve No. 40 is used only to adjust the capacity to suit the need of the boiler, as the automatic adjustment of the water supply to suit all variations of the pressure of the steam by the inter-action of the two steam jets prevents waste at the overflow valve.

During the operation of the injector as described above, it is assumed that the temperature of the water supply is normal, but when it exceeds that with which the injector will operate without wasting, the overflow valve No. 30 must be locked, and all subsequent overflow from the tubes will fill the overflow chamber and cause an external pressure upon the jet. The highest admissible temperature of the water supply will then be limited by the power of the jet of water when crossing the openings of the forcing combining tube to withstand the lateral pressure of the contained fluids in the overflow chamber No. 25. The lower the velocity of the jet, the more sensitive it is to external pressure, so that if the openings at the widest part of the tube near the steam nozzle are protected, the jet can then withstand a higher pressure and the temperature of the water supply is still further increased.

In the Class *K* (lifting or non-lifting) forms of this injector the upper opening of the combining tube near the steam nozzle is protected by a special automatic valve No. 98, shown in Fig. 3. This injector permits the use of a water supply reaching a temperature of 147° at 200 lbs. steam, which is 22° higher than the limit of the form shown in Fig. 2.

The high-pressure tests were made with steam taken from a 300 h.-p. "Babcock and Wilcox" boiler, capable of carrying 300 lbs. to the sq. in.; tests at the lower pressures were made with the same injector and tubes, connected to a low-pressure boiler in order to avoid superheating the steam by excessive throttling. A separator was placed in the steam pipe, lagged and carefully drained. The water in the supply tank between point levels was weighed and continually re-checked; all thermometers and gauges were accurately calibrated; observations and readings were taken by three operators. As soon as a test was made the result was plotted on a temporary diagram to determine its correspondence with previous operations; if found to vary from the general trend of the curves, it was repeated, and errors thus eliminated as far as possible. In the final diagrams the curved lines connect the individual observations and are extended above and below the limit of experiments

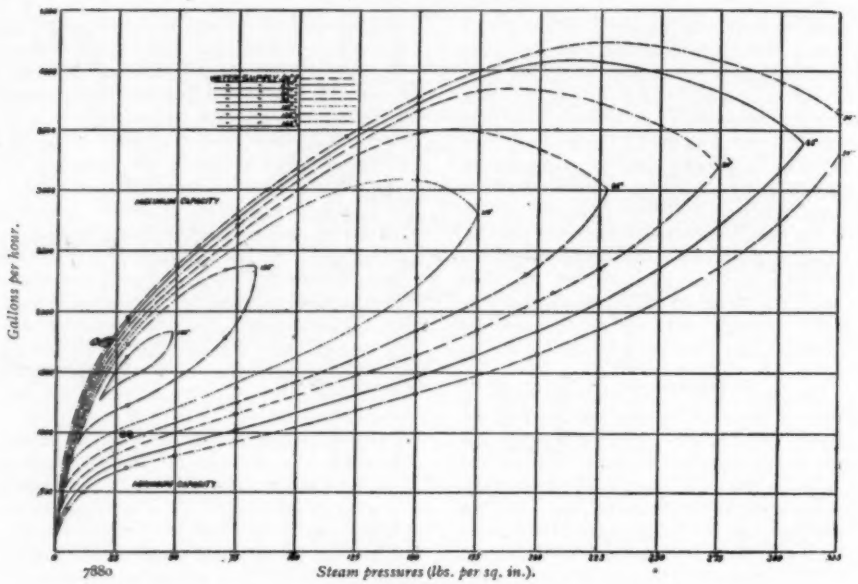


DIAGRAM I.

according to the general tendency of the established curves. In each diagram the abcissae indicate the gauge steam pressures per sq. in. and the vertical ordinates, gallons per hour, degrees Fahrenheit, etc. The points on the curves at which the experiments occur are denoted by small circles.

Diagram I. shows graphically the maximum and minimum capacity at steam pressures ranging from 2 lbs. per sq. in. to 325 lbs., when the temperature of the water supply is 50°, 65°, 80°, 95°, 110°, 125°, and 140°; the injector in each case operating with the overflow valve free to open, to permit automatic re-starting. The vertical scale indicates gallons per hour from 0 to 4,500, and the horizontal scale, steam pressures from 0 to 325 lbs.

From diagram I. can also be obtained the range of capacities for any desired steam pressure and water supply temperatures, by subtracting the values given by the curved lines; for example, when the boiler pressure is 200 lbs., and the water supply 65°, the maximum capacity is 4,068 galls. per hour, and the minimum 1,846, giving a range of 2,222. The overflowing temperature is that point at which no regulation of the water supply will prevent the emission of drops of water at the overflow; it therefore corresponds to the temperature at which the maximum and the minimum capacities coincide; this is indicated by the pointed junction of the maximum and minimum lines on the diagram for any given condition; for example, at 275 lbs. boiler pressure, the overflowing temperature is 80°; at 175 lbs., 110°; points not shown on diagram may be interpolated, but are more clearly shown in diagram II., where the temperature tests are specially plotted.

The results shown on diagram I. are of much interest, and clearly show the remarkably high capacities given by this form of injector at steam pressures varying from 175 lbs. to 250 lbs. The upward course of the line of maximum capacities corresponds closely to the theoretical line for perfect efficiency,

based upon the well-known formula for efflux of water, $V = 2\sqrt{gh}$, the divergence being greatest at the high pressure. The tests were made with a single set of tubes for all pressures, operating as low as 2 lbs. steam and tested as high as 250 lbs.; the extensions of the capacity lines show the performance at still higher pressures.

Diagram II. shows the limiting temperatures of the water supply. First, the overflowing, or maximum temperature of water with which the injector can start automatically, and second, the highest temperature of water supply with which the injector can operate.

In service, when the temperature exceeds that at which the water appears at the overflow, the overflow valve No. 30 is forcibly held to its seat by rotating the cam No. 31, by means of the lever No. 34, thus preventing the escape of water or steam. The temperature of the water supply may then be raised to the upper limit without interfering with the action of the injector. When the boiler pressure is 200 lbs., the limiting re-starting temperature is 104°, while the maximum admissible temperature is 125°. As indicated on the preceding diagram, the most efficient steam pressure for warm water is about 32 lbs., when the two limits are 145° and 147°. The peculiar offset to the curve between 75 lbs. and 125 lbs. is due to the action of the supplemental inlet valve, which permits an additional supply of water to enter the forcing combining tube without being subject to the heating action of the steam from the first or lifting nozzle; this supplemental supply is drawn from the suction pipe through the overflow chamber (25) containing the forcing combining tube (2) and into the opening in that tube instead of

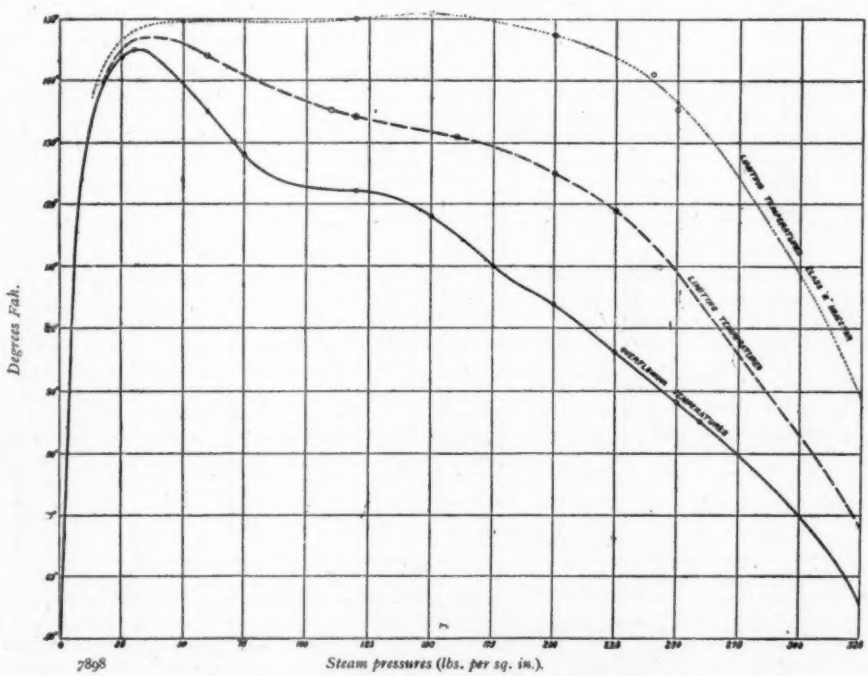


DIAGRAM II.—LIMITING AND OVERFLOWING TEMPERATURES, 25 INCHES LIFT.

entering the mouth of the combining tube with the main supply.

The above limits of temperature are sufficient for all ordinary requirements, but the Class *K* form of the self-acting injector, which has already been referred to in the description of Fig. 1, is designed to meet still more severe conditions. The upper dotted line shows the capabilities of this injector, which exceed the limits of temperatures of the usual self-acting form by 20° to 28°, between 150 lbs. and 250 lbs. steam pressure. At 200 lbs. it can lift and deliver to the boiler when the water supply is 147° F. and 135° at 250 lbs. pressure. The non-lifting form is shown in Fig. 3.

Diagram III. shows graphically the wide range of the injector by expressing the minimum capacity in terms of the maximum. The horizontal scale indicates steam pressures from 0 to 325 lbs., and the vertical scale percentages from 35 to 100. As the top line of the diagram is 100 per cent., it shows the extreme limit of pressure for any given temperature of water supply and corresponds to the pointed intersection of diagram I., while a point on any curved line gives the definite value of the relation between two points on any vertical line for the corresponding maximum and minimum lines of diagram I. For example, at 275 lbs. steam, the minimum capacity is 100 per cent. of the maximum at 80°, as shown by the overflowing temperature in diagram II., or the pointed intersection of the 80° line of diagram I.

The widest range is obtained, as should be supposed, with coldest water —namely, 50° — and is at 100 lbs. steam when the minimum is 35 per cent. of the maximum. At modern locomotive boiler pressure, 200 lbs., water supply 65°, the minimum capacity is $45\frac{3}{10}$ per cent. of the maximum, giving an actual permissible variation of the capacity of 2,222 galls. per hour.

The mechanical efficiency of an injector is measured by the ratio of the

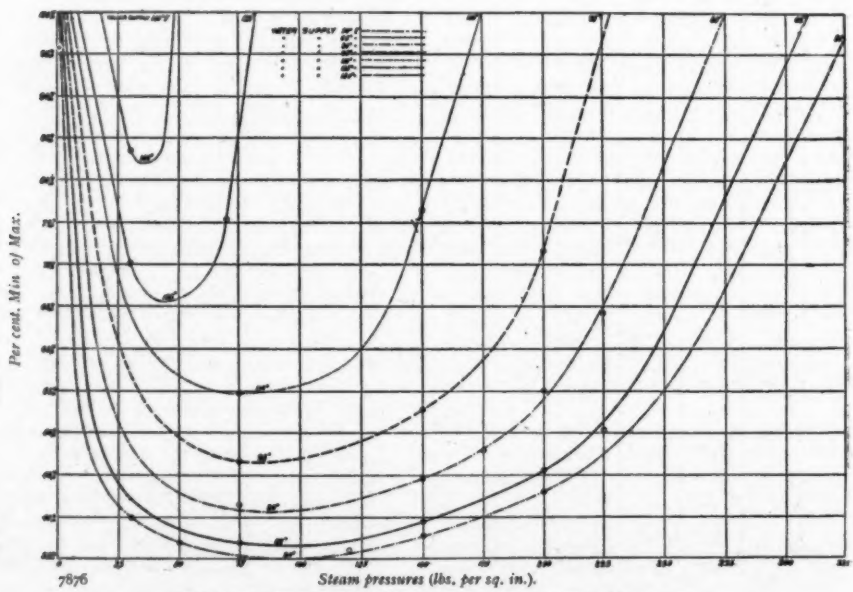


DIAGRAM III.—MINIMUM CAPACITY IN PER CENT. OF MAXIMUM CAPACITY

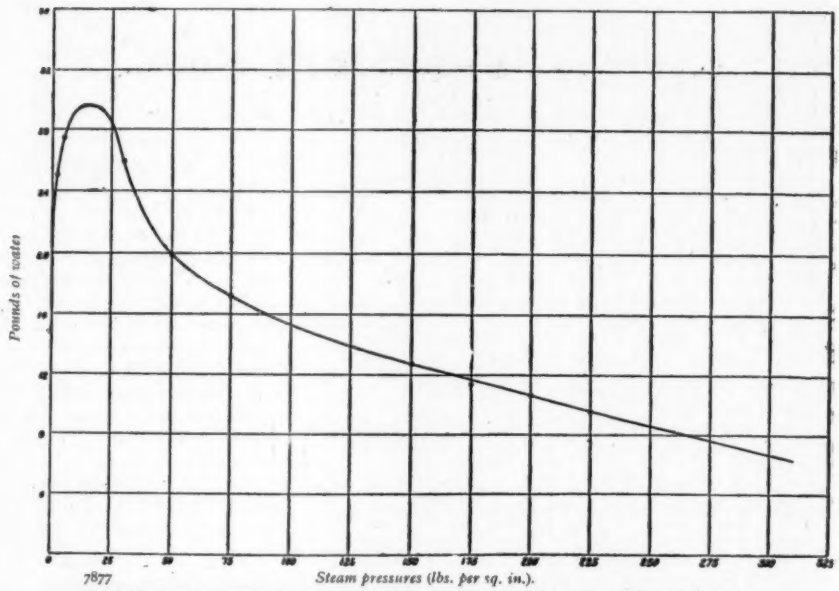


DIAGRAM IV.—POUNDS OF WATER DELIVERED PER LB. OF STEAM. WATER SUPPLY 65° FAH.

weight of supply water to the weight of steam used. This ratio is shown in diagram IV., where the vertical scale represents pounds of supply water delivered per pound weight of steam, and the horizontal scale, gauge pressure in pounds per sq. in. As was noticed on the previous diagrams, the higher pressures do not show the action to be as effective as at low steam. It is probable that with an ideal injector, or one in which the entering areas of water and steam could be modified to suit every variation of pressure, the curve on diagram IV. would extend its parabolic tendency upward until it approached tangency with the vertical ordinate of 0 pressure. The values shown, however, are exceptionally good, and indicate a high efficiency for this kind of steam-operating device. At 200 lbs. pressure, water supply 65°., 10·7 lbs. of water are drawn from the supply tank and delivered for each pound weight of steam taken from the boiler.

In conclusion, it may be said that the complete record of tests, as shown on the diagrams, indicate an unusually efficient injector through a wide range of conditions. The same set of nozzles were used in all tests, from 2 lbs. steam pressure to 250 lbs., a far wider range of pressures than would be required in practice.

Electrical Engineering Notes.

By ANDREW STEWART, A.M.I.E.E.

The Conversion of Standard Steam Railway Rolling Stock to suit Electric Traction.

The Metropolitan Railway have now put into service trains made up of steam railway rolling stock, and their example cannot fail to prove of interest to those railway officials who contemplate electric traction, but hesitate lest such a step should render obsolete much of the rolling stock they now have, a large proportion of which may be quite modern. When electrification was completed the company in question found themselves in possession of nine trains, each of seven coaches, which were built as recently as 1900. The inadequate seating accommodation of the new rolling stock encouraged them to make the experiment of electrifying two of these trains, and this was effected by placing the front and rear coaches on new bogies, and using the guard's compartment for the accommodation of the rheostats, controller, and so on. The conversion rendered necessary a modification of the under-frames to allow of the inspection of the motors, &c., but it will be apparent from Fig. 2 that no very serious change has taken place

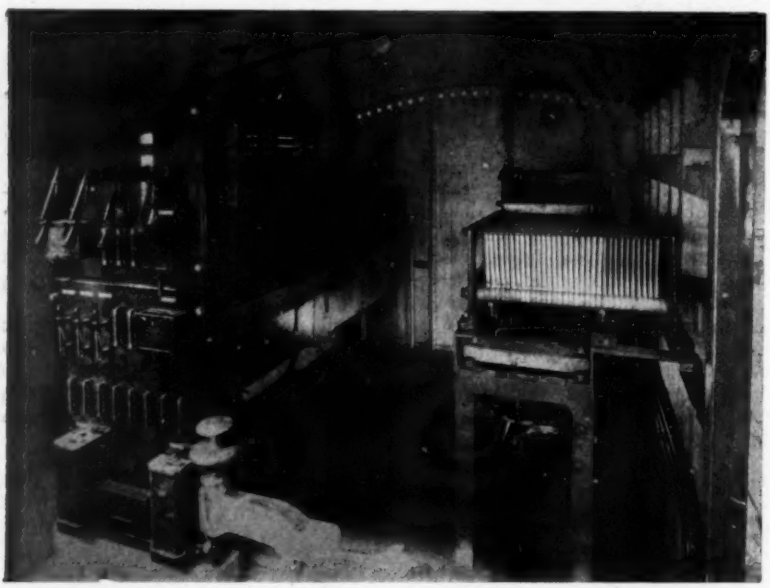


FIG. 1

Interior view of motor man's compartment, showing contactors, resistances, switchboard, etc. In the immediate foreground is the handle of the controller equipped with the emergency automatic stop button, which, if released by the driver from any cause, cuts off the current to the motors, and brings the train to a standstill.

in the outward appearance of the vehicle.

The new bogie trucks for these coaches have 38 in. wrought centre, steel-tyred wheels on 6½-in. axles, the wheel base being 7 ft. The motors are standard type G. E. 69, rated at 200 h.-p. each, one on each axle, so that there are four motors on the front coach and four on the rear coach, giving a total of 1,600 h.-p. per train, enabling a maximum speed of 45 miles per hour to be attained, and a schedule speed of 16 miles per hour maintained under service conditions. The interior view of the motor man's compartment is shown in Fig. 1.

The complete motor coach weighs 38 tons 2½ cwts.; each trailer weighs 19 tons 2 cwts. As there are two motor coaches, and five ordinary carriages, or trailers, the entire train weighs 171¾ tons, seating 280 third and 120 first-class passengers. The underside of the floors of the motor coaches are sheeted over with ¼ in. uralite, and the upper surface is covered with a layer of Paris cement, such as is used for the floor of the present steel cars on the Metropolitan Railway. A similar cement floor has been fitted to the ordinary coaches in place of the wood floor formerly used.

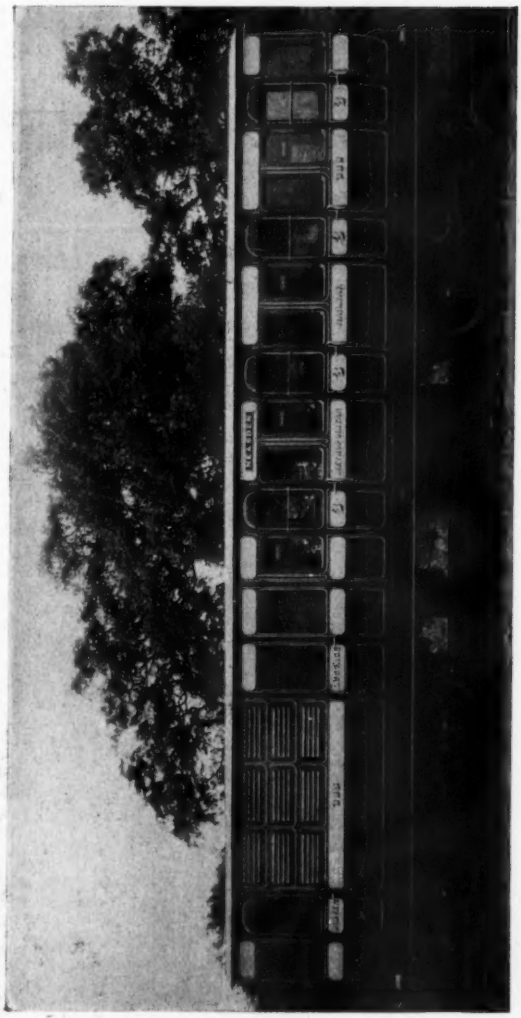


FIG. 2.—COMPLETE MOTOR CAR.

Automatic quick-acting air brakes have now been fitted, replacing the vacuum brakes formerly used. The air compressors are by the British Thomson-Houston Co., and consist of enclosed series motors driving through double helical gearing, two single-acting cylinders capable of supplying 25 cubic feet of free air per minute.

Fig. 2 shows a complete motor car.

Electric Power in Factories.

One of the considerations which the works owner and manager must face when the introduction or extension of electric

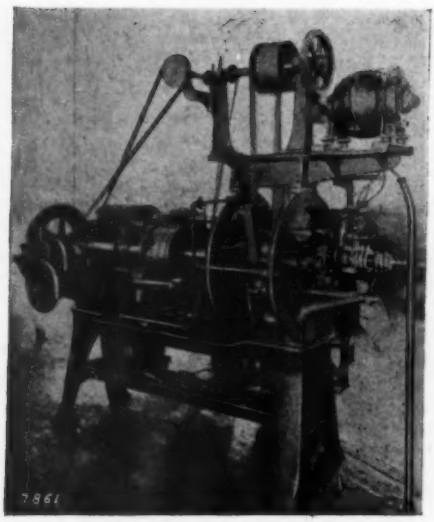


FIG. 3.—MOTOR DRIVEN AUTOMATIC SCREWING MACHINE.

power is contemplated is the adaptation of machine tools to the new drive. It is not always that an electrically-driven factory can start with a clean slate, as most tools in a well-managed engineering works are in a fair state of preservation, if not actually modern. In any case, the high price of machine tools with the electric motor built into the framework is sufficient to deter buyers, whose capital is limited, from purchasing them, and lead them to adapt the standard machine to the motor which drives it, or *vice versâ*.

The efforts of the F. Wesel Manufacturing Co., of Brooklyn, U.S.A., in this direction have proved so successful that illustrations of the most interesting machines will no doubt prove of value to our readers.

The works, which, by the way, produce platers' and stereotypers' machinery, have had 192 motors installed, mostly of ½ and 1 h.-p., only nine machines requiring motors over 5 h.-p. The method adopted in attaching the motor to an automatic screwing machine is shown in Fig. 3. The motor and its reducing gear are carried on two braced rings which clear all the mechanism of the headstock. The supply cable is brought up in a pipe from the floor. Fig. 4 shows a row of milling machines, the motor being carried on a bracket bolted to the top of the machine. The motor drives a step pulley through a spur gear; the starting switch and double pole fuse will be seen on the top of the machine under the step pulley. As the starter is in an inaccessible position for the operator, a push button is provided on the column, close to the table, so that the machine may be stopped by merely pressing the button. The wiring on the machine is protected by flexible metallic tubing, which is more easily fitted than the conduit tubing used in this country.

FIG. 5.—PLANERS WITH ELECTRIC MOTORS ON COLUMNS.

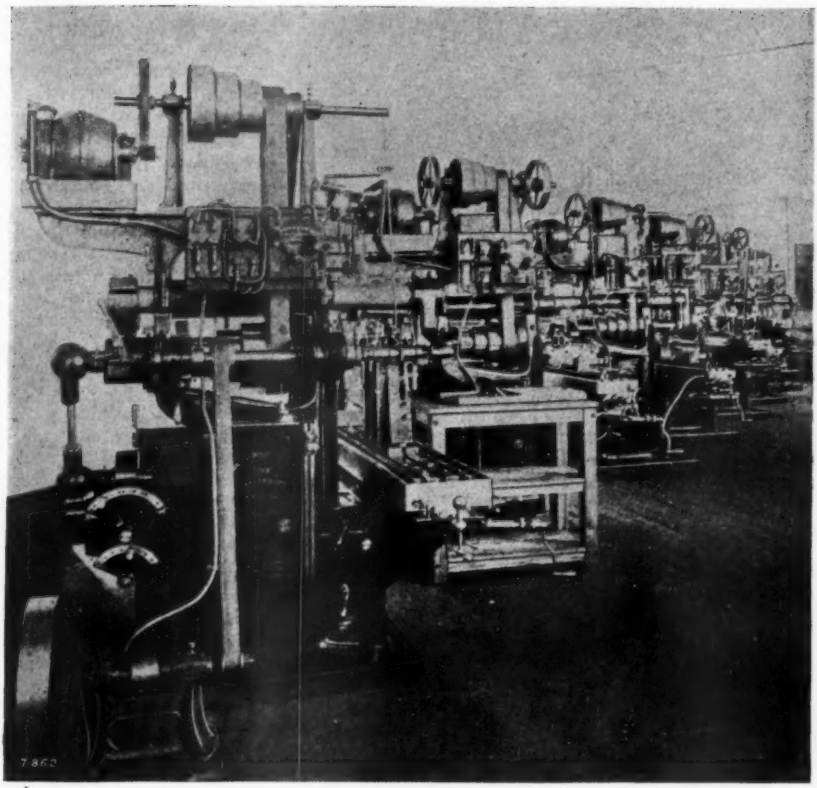


FIG. 4.—MOTOR DRIVEN MILLING MACHINES.

As will be seen from the illustration, the machines are staggered in order to economise space and secure adequate light.

The electrically-driven planers (Fig. 5) are interesting, inasmuch as the work of adaptation has been carried out very thoroughly by casting two brackets which fit the planer uprights, on which a superstructure, consisting of two brackets which carry a shaft, having the driving pulleys at either end, is erected. The motor drives the shaft through spur gear. Most of the pulleys used were formerly employed when the planer was mechanically driven; the right-hand pulley operates the raising and lowering gear on the crosshead, while the left-hand pulley drives the table. It is unnecessary to reverse the motor, the reversal being obtained on the fast and loose pulleys in the usual manner.

The method of lighting the planer by carrying a piece of conduit from the machine column, from which another piece swings, at the end of which is the lamp, is interesting. A similar arrangement is shown (Fig. 6) for lighting a lathe.

Figs. 6 and 7 show electrically-driven lathes. The former shows the motor bracket bolted to the back of the lathe, behind the headstock, while Fig. 7

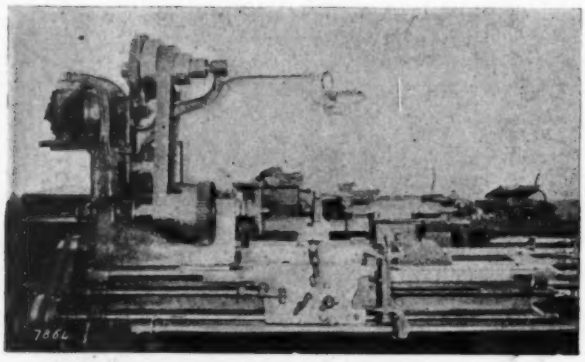


FIG. 6.—ELECTRICALLY DRIVEN LATHE SHOWING METHOD OF LIGHTING.

shows an arrangement pretty much the same as that used for the automatic screwing machine (Fig. 3). Applying a motor to a lathe in the manner indicated by Figs. 6 and 7 introduces the difficulty that the brackets are likely to interfere with some particular gear combination, as the back gear shaft occupies a different position in various gears; this is further complicated if it is a screw-cutting lathe. In order to overcome this possible source of trouble the shop superintendent got out a rough drawing of the proposed casting and had a pattern made; this was fixed to the lathe, and all possible combinations of the gear tried. Alterations were, of course, made until the brackets were clear of all possible gear combinations; these were then cast, the remaining gear assembled, and the whole fixed to the lathe in a few minutes, thus avoiding withdrawing the machine from service for any length of time.

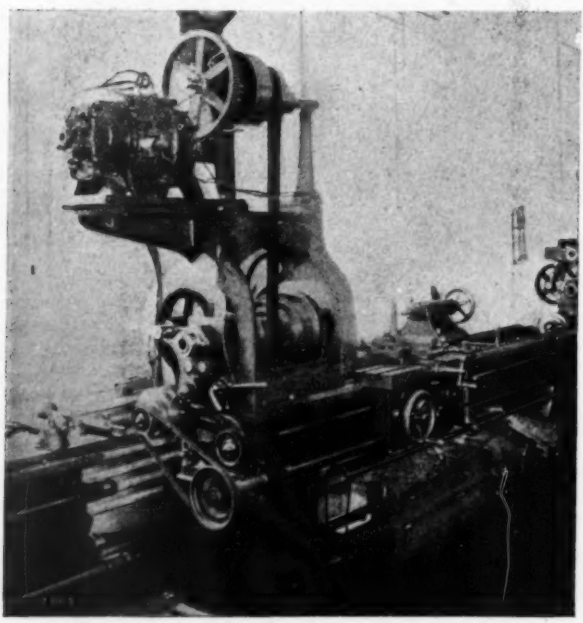


FIG. 7.—ELECTRICALLY DRIVEN AUTOMATIC SCREWING MACHINE.

The motor is controlled from the tool rest, by the wheel seen fixed on the right-hand side of the rest, and acting through bevel gear on to the splined rod which runs the whole length of the machine parallel to the feed screw; this rod has a sprocket wheel and chain which communicates the motion to the controller seen mounted on one leg of the lathe, at the extreme left of the picture.

Fig. 8 shows a motor-driven boring mill, where a somewhat similar method of driving has been adopted. The design of the brackets are, however, slightly different, while Fig. 9 shows clearly how easily a radial drill may be adapted to electric driving.

The outstanding feature of these illustrations

is the compact nature and ingenuity of the modifications introduced to make the tools equivalent to the most modern self-contained machine tools. In this respect the examples go to prove that, given an ingenious designer and some motors, no works owner need despair of obtaining all the advantages of electrically-driven tools at a comparatively small capital outlay.

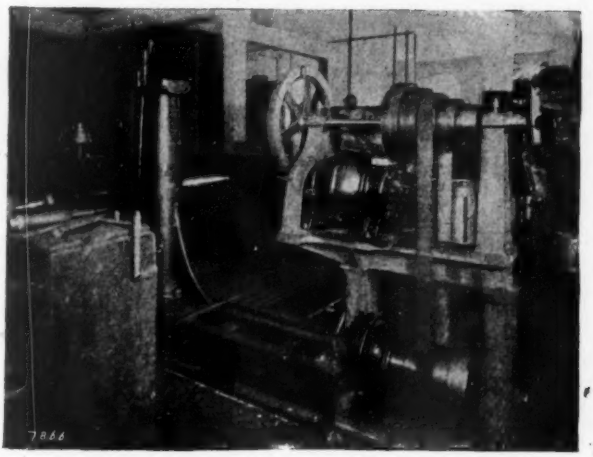


FIG. 8.—ARRANGEMENT OF MOTOR DRIVE FOR BORING MILL.

The Line Equipment of the Electrified Section New York Central Railway.

In our last issue (p. 368) we described one of the power stations for the electrified portion of the above lines. This scheme of electrification is the most expensive and complete hitherto undertaken by any railway, involving the immediate electrification of the main line for a distance of 17 miles, and the reconstruction of the terminal station, at a cost of about seventeen million pounds.

The ultimate capacity of the two

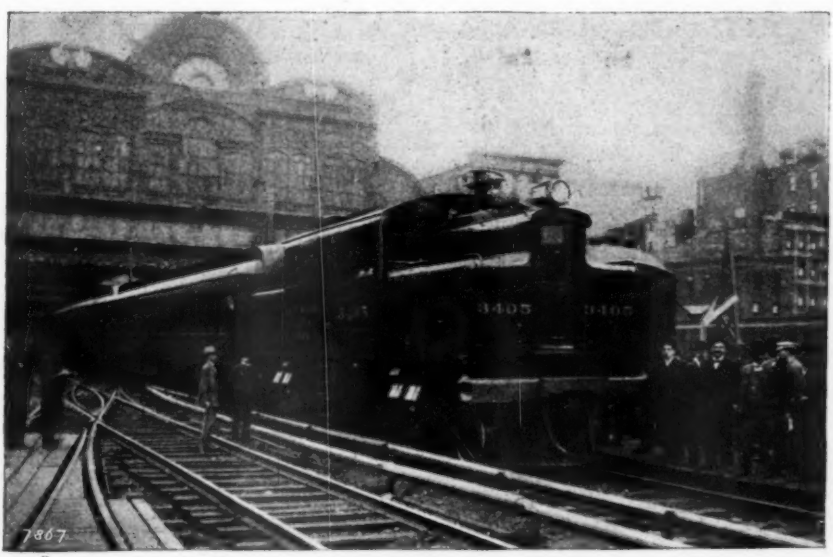


FIG. 9.—ELECTRIC TRAIN RETURNING FROM GRAND CENTRAL STATION, NEW YORK CENTRAL RAILWAY.

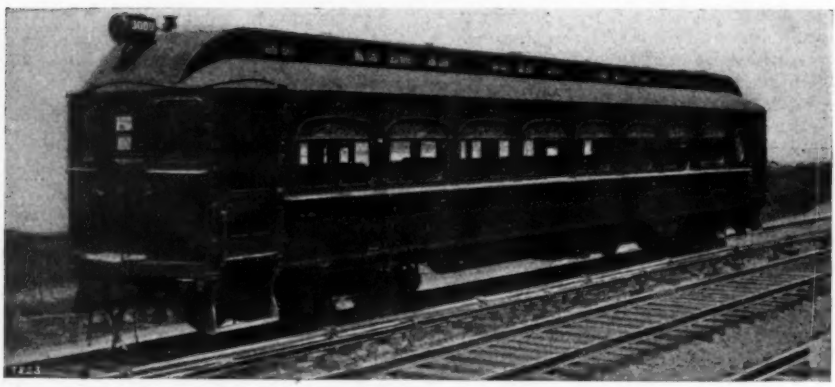


FIG. 10.—STEEL SUBURBAN MOTOR CAR, NEW YORK CENTRAL RAILWAY.

main generating stations will be 84,000 h.-p., which will be supplied by Curtis steam turbines in units of 7,000 h.-p. each. For the initial electric zone (17 miles) there will be four rotatory converter sub-stations, which number will be doubled when the entire system is electrified. Thirty-five electric locomotives weighing 100 tons, and capable of exerting 2,200 h.-p., are built or building, and 125 motor coaches of 400 h.-p. each will be employed on the suburban lines, while six motor combined baggage and passenger cars will also be built, so that there will be 221 locomotives and motor cars, aggregating 129,000 h.-p., for handling the traffic. The main line trains will attain a speed of 40 to 80 miles per hour, depending on the weight behind the locomotive, while the maximum speed of the suburban cars will be 52 miles per hour.

Fig. 9 shows an express train with one of the 2,200 h.-p. electric locomotives attached, while Fig. 10 shows one of the 400 h.-p. all-steel suburban motor-cars. Fig. 11 shows

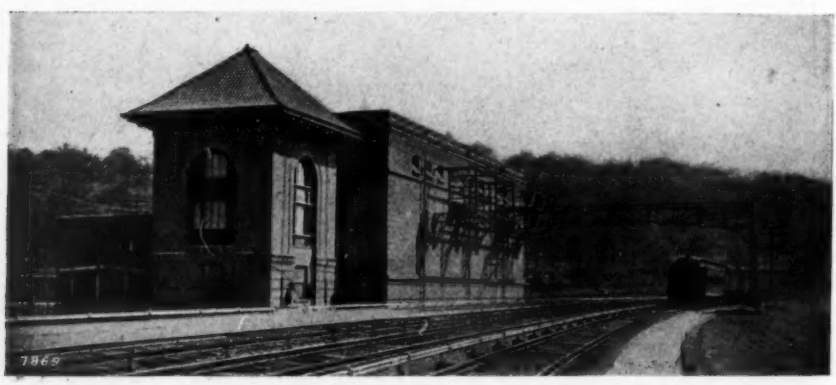


FIG. 11.—KINGSBRIDGE SUB-STATION, SHOWING TRANSMISSION LINES AND TRACK, NEW YORK CENTRAL RAILWAY.

the Kingsbridge sub-station; the track and third rail can be clearly seen. The sub-station contains the rotatory converters on the ground floor, and a battery floating on the line on the upper floor.

Motor Engineering.

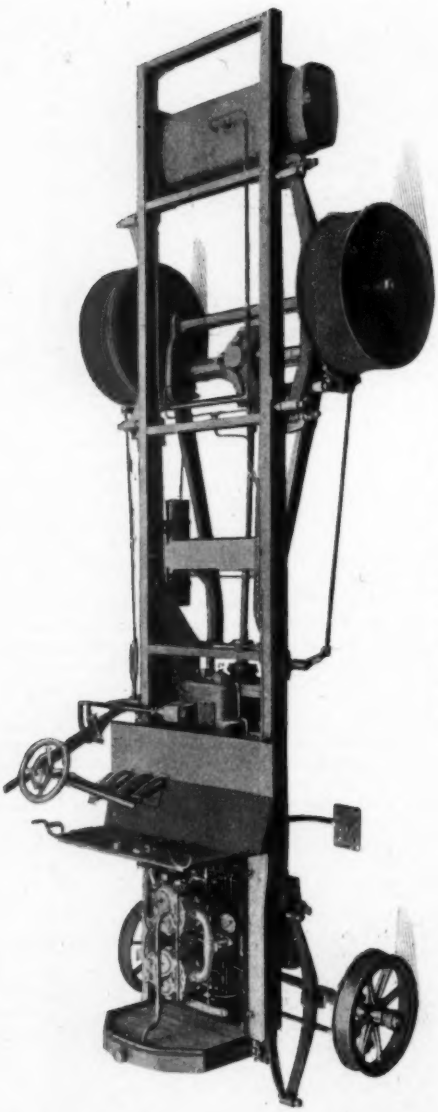
By R. E. PHILLIPS, A.M.Inst.C.E., M.I.Mech.E.

Commercial Motors at Trade Exhibitions.

No surer indication of the hold that motor vehicles have obtained in the commercial world is wanting than the patronage extended to the various trade exhibitions by builders of commercial motor vehicles. At the late Brewers' Exhibition at the Agricultural Hall, seven firms—viz., Messrs. William Allchin, Limited, of Globe Works, Northampton; Mann's Patent Steam Cart and Wagon Co., Ltd., of Hunslet, Leeds; The St. Pancras Iron Works Co., Ltd., of St. Pancras Road, N.W.; Messrs. Moss & Wood, Oaklands Road, Cricklewood; The British Automobile Commercial Syndicate, Ltd., of 98, Long Acre, W.C.; Messrs. Foden & Co., of Sandbach; and Mr. John Goode, of Alderman's House, Bishopsgate Street Without, E.C.—exhibited motor vehicles specially constructed for commercial purposes. The 5-ton steam wagon exhibited by W. Allchin, Limited, does not differ materially from their already well-known type. In the latest type of Mann 5-ton steam wagon the smoke-box door, instead of projecting forward between the fuel bunkers, is now hidden by a continuation of the sheet metal forming the front of the bunkers, which is carried right round the front of the boiler. In the screen is a large door which gives access to the smoke-box door. The 5-ton steam lorry exhibited by the St. Pancras Iron Works Co. is of a new type, one of the features of which is that the tracks of each pair of wheels are the same. The engine is compound, and has a new type of valve for supplying both steam chests with high-pressure steam when required. In the 24 h.-p. 3-ton chassis, exhibited by Messrs. Moss & Wood, two vertically arranged radiators are employed, one for each cylinder, and the engine, which has two horizontally opposed cylinders, vertical valves are now employed, which are operated by a cam shaft driven from the crankshaft by skew gearing. The exhibit of the British Automobile Commercial Syndicate—a 20 h.-p. "Spyker" van—was conspicuous by reason of the novel form of its body, which represents a beer bottle lying horizontally as is intended for a travelling advertisement of a well-known firm of brewers, the sides of the bottle bearing enlarged representations of the company's label. The Foden wagon exhibited was of the standard type, but it contained one new feature of considerable merit, viz., a trailer brake attachment which enables the brakes of the trailer to be applied from the platform of the tractor. A vertically arranged hand wheel is connected to a screw which operates a steel cable acting on the brake mechanism of the trailer. The exhibit of Mr. John Goode included a 3-ton "Latil" motor lorry and an 8-ton "Lomas" steam tractor. Both these have so many novel points that we shall defer any description of them until a later date, when we can fully illustrate them.

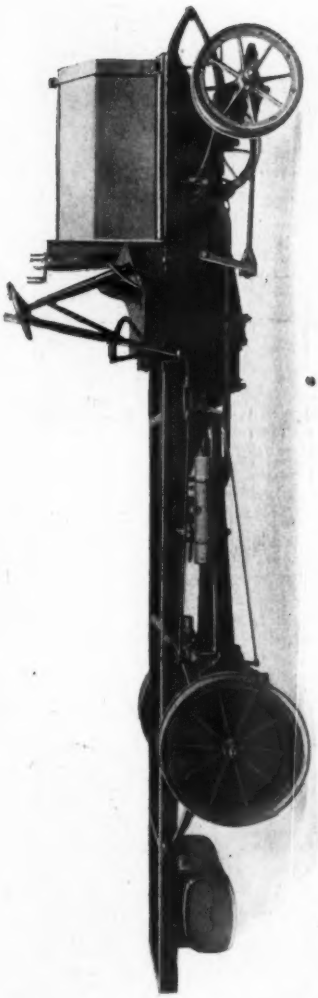
The New 28 H.-P. "Milnes-Daimler" Chassis.

This chassis differs materially from former models, and there is little reason to doubt but that the alterations made are the outcome of the extended use to which this firm's chassis has been put in this country in connection with public service vehicles. The frame of the new chassis is constructed of pressed steel instead of rolled channel steel as in former patterns. The side members of the frame have a maximum depth of 6 ins., and taper slightly towards the ends. There are five cross stays also of pressed steel, the one



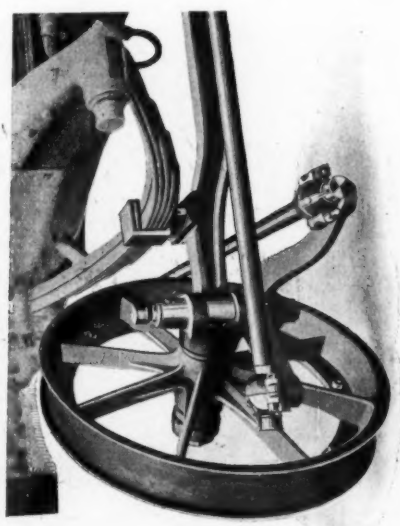
THE NEW 28 H.-P. "MILNES-DAIMLER" CHASSIS.

that carries the forward ends of the radius bars being in the form of a deep girder. The back springs, which are now outside the frame, are 4 ft. 2 ins. long, and have nine leaves 3 ins. wide. The front springs are 3 ft. 4 ins. long, and have five leaves 2¾ ins. wide. Screw-down greasers are now fitted to the pins of the shackles of the springs, and these, and also all others throughout the chassis, have the box part formed in one with the part to be lubricated, so that only the caps are loose. The back axle, which is now straight, is of H section, the journals for the wheels being 3 ins. diameter and 8⅞ ins. long. The front axle is also of H section, the journal being 2¼ ins. diameter and 6¾ ins. long. The principal dimensions of the frame are; Length, 19 ft. 11 ins.; wheel base, 13 ft.; wheel track, 5 ft. 6 ins.; height from ground unladen, 2 ft. 10 ins.; width over axle caps, 6 ft. 6½ ins. The radius bars, which in the old chassis were of wood, are now made of pressed steel, and instead of being arranged parallel, as before, are now brought in at the front ends to within about 15 ins. of each other, and are pivoted to the frame on the centre line of the universal joint at the forward end of the cardan shaft. The differential axle is now so mounted on the radius rods that it can be dismounted and taken down without disturbing the radius rods. Three brakes are now fitted—the third or new brake—which is applied by the hand lever, consisting of brake blocks 12 ins. long with V shaped working faces which engage correspondingly shaped grooves on the inner edge of the rims of the rear wheel. The other two brakes, which are operated by foot pedals, are of the strap and drum type. The one acts on a drum fixed on the forward end of the secondary shaft in the gear box, and the other acts on a pair of drums on the differential shaft, all the drums being the same size, viz., 10½ ins. diameter by 2¾ ins. wide. The old type of transmission is retained, viz., by pinions on the ends of the differential shaft, engaging internal toothed rims on the driving road wheels. We are surprised at this in view of the difficulty of suppressing the noise resulting from the conditions under which this type of gear works. A new detail in the transmission gear is the construction of the universal joint at the rear end of the cardan shaft. This consists of a pinion with specially shaped teeth which is fixed on the end of the cardan shaft, and which fits loosely in a box having internal teeth of a corresponding shape, the box forming the front end of the short shaft which drives the differential

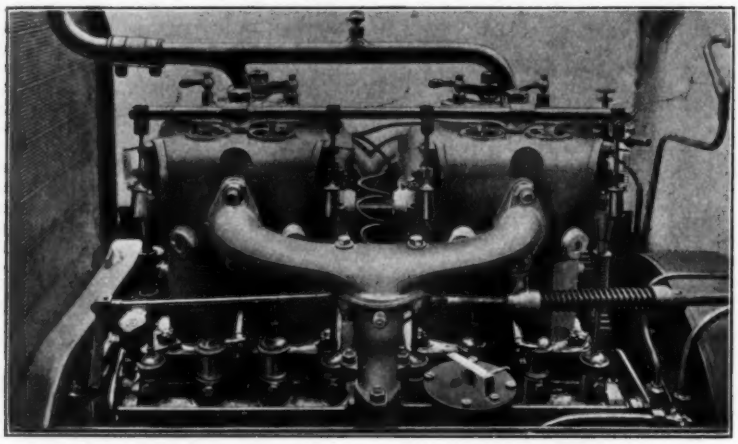


SIDE VIEW OF THE NEW 28 H.P. "MILNES-DAIMLER" CHASSIS.

gear. The gear box is of the old type, designed to give the following gear ratios with the engine running at its normal speed, viz., 2½, 5, 8½, and 12 miles an hour. The engine, which develops 28 h.-p. at its normal speed, about 800 revolutions per minute, has four cylinders cast in pairs, the bore being 4 5/8 ins. and the stroke 5½ ins. The pairs of cylinders are placed sufficiently far apart to enable a central bearing to be employed for the crank-shaft. The pistons, which are ground into the cylinders, have their annular oil distributing grooves one on each side of the gudgeon pin and one near the lower end. The big ends of the connecting rods are fitted with brasses lined with anti-friction metal, and have six radial oil ducts. The crank-shaft is cut out of a solid slab of chrome-nickel steel. The parts running in the three bearings are 1⅞ ins. diameter by 4 ins. long, while the crank pins are 1¾ ins. diameter and 3 ins. long. The cams on the valve operating shafts are cut out of the solid. The crank chamber is of cast-iron of an exceptionally strong design. The radiator is of the honeycomb type, and is attached to the frame by two universal joints, one on each side, so that any twist in the frame is not imparted to it. A very efficient gear-driven water circulating pump is employed. At the normal speed of the engine the pump makes 1,420 revolutions per minute, which passes 17 gallons of water per minute, sufficient to circulate the whole of the water three times a minute. The lubrication of the engine is by means of a small force pump driven by a crank on the rear end of the inlet valve cam shaft. Three pipes lead from the pump, one to each of the bearings of the crank-shaft. The crank-shaft, which is bored throughout, is plugged at two places so that it has three distinct chambers, two each comprising the one end of the crank-shaft and

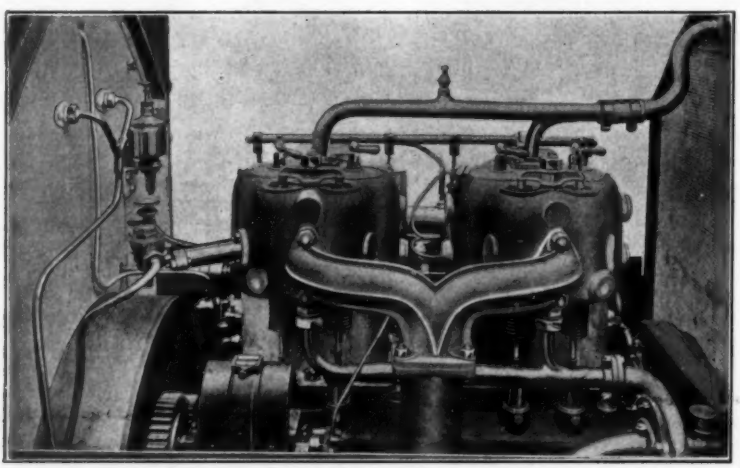


NEW "MILNES-DAIMLER" CHASSIS: FRONT AXLE, WHEEL, SPRING, &C.

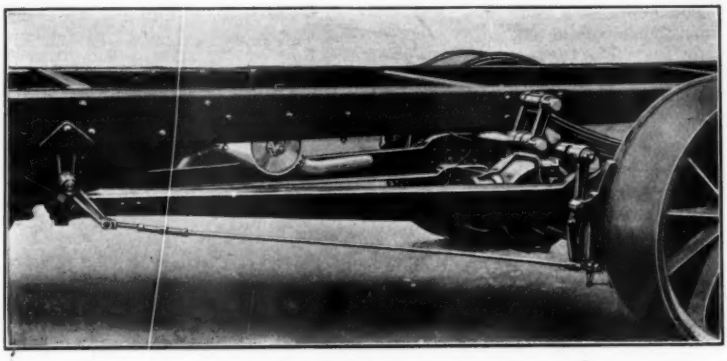


28 H.-P. ENGINE, "MILNES-DAIMLER CHASSIS.

the adjacent crank pin, and the third the central part of the crank-shaft and the two adjacent crank pins. The oil from the pump passes to the three bearings, from whence a portion finds its way into the compartments of the crank-shaft, and thence through suitable ducts to the bearings of the big ends of the connecting rods. The surplus oil falls to the bottom of the crank chamber, and thence through a strainer to a reservoir, from which the pump draws, so that there is a constant circulation with no waste. An indicator on the dashboard shows the working of the pump. The magneto is now fixed to the frame by a strap so that by undoing a single bolt it can be removed. It will be seen that the dashboard presents a very clean appearance, there being an almost entire absence of the usual paraphernalia.



ANOTHER VIEW OF THE ENGINE.



RADIUS BARS AND REARWHEEL BRAKE "MILNES-DAIMLER" CHASSIS.

The Automobile Club Town Carriage Trials.

The result of these trials shows up conclusively the folly of manufacturers of motor-cars propelled by internal combustion engines pitting their productions against electric and steam vehicles, when the price and running cost are not taken into consideration in arriving at the result of the trials, for an electric vehicle takes the first award in each class, and electric and steam vehicles take five main awards out of seven in the two classes.

The awards are as follows:—

Class "A" for vehicles costing up to £600 complete:—Electric vehicle, No. 31, entered by Mr. Carl Oppermann, gold medal; "Limousine" car, No. 27, entered by the Wolseley Tool and Motor-car Co., Ltd., gold medal; public service vehicle, No. 26, entered by the City and Suburban Cab Co., Ltd., silver medal.

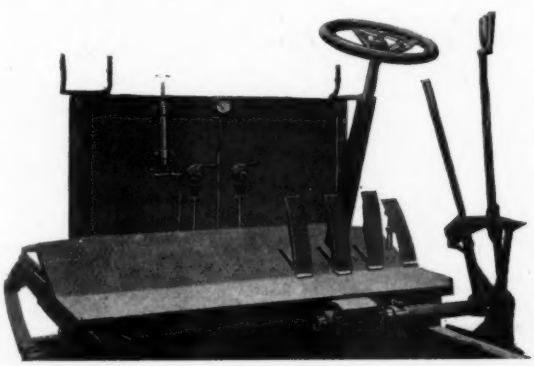
Class "B," for vehicles costing over £600 complete:—Electrically-propelled vehicles, Nos. 7, 8, 9, 10, entered by the Electromobile Co., Ltd., gold medal; "White" steam cars, Nos. 1 and 2, entered by Mr. Frederic Coleman, gold medal; "C. G. V." car, No. 13, entered by the London Motor Garage, Ltd., silver medal; Electric vehicles, Nos. 17 and 18, entered by the Krieger Electric Carriage Syndicate, Ltd., silver medal.

In addition the following awards were made:—

In Class "A," Adams' Manufacturing Co., Ltd., car No. 32, for ease of manœuvring, silver medal.

In Class "B," London Motor Garage, Ltd., "C. G. V." car, No. 13, for excellence in carriage work, silver medal; Messrs. Dennis Bros., Ltd., car No. 14, for comfort to passengers, silver medal; The Pilgrim's Way Motor Co., Ltd., car No. 12, for originality in design and accessibility, silver medal.

We consider that trials held on these lines serve no useful purpose, but only tend to mislead the buying public, to whom both the initial cost and the cost of running and maintenance are matters of vital importance. In eliminating these two factors from the trials we fear the Automobile Club has been influenced by the trade. If the club is to retain its prestige in the holding of trials, it should consider the public, and the public



VIEW OF DASHBOARD.

only. Past experience in trials has shown that only those conducted independent of the trade to which they appeal establish any reputation or carry any weight with the public.

The Motor-van.

Our contemporary, *The Commercial Motor*, in a recent issue, dealt at length with motor-vans for commercial purposes, giving a number of interesting communications on the subject from users of such vehicles, and the facts elucidated from these communications are so important and the figures summarised from them so vital that we do not hesitate to reproduce them. Dealing with the question of replacing horse-drawn vans with motor-vans, our contemporary sums up the situation as follows: "The principal considerations which contribute to the desired result of high performance, coupled with economy, and any one of which may turn the scale largely in favour of the motor vehicle, are: (a) ability to attract fresh trade, by reason of (1) the advertisement value, (2) more prompt attention to orders, or (3) regular delivery to, and general convenience of, customers; (b) lower cost for equal amounts of work done, regarded

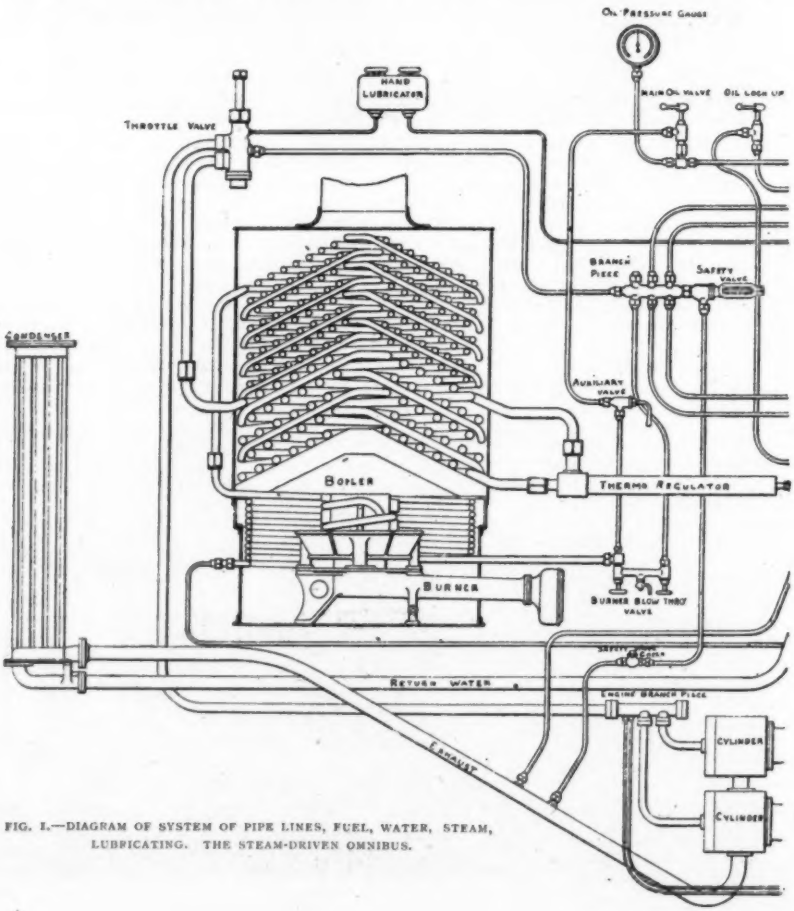


FIG. 1.—DIAGRAM OF SYSTEM OF PIPE LINES, FUEL, WATER, STEAM, LUBRICATING. THE STEAM-DRIVEN OMNIBUS.

in conjunction with the elimination of numerous uncertainties associated with the ownership of horses; (c) capacity to maintain a high daily average mileage in hilly country without rest intervals; and (d) occasional use of the vehicle, after change of the body-work has been effected, for private purposes or for hiring services"; and it then gives the following short summary of costs and performances arrived at from a large volume of working data:—

Motor.	Load.	First cost.	Weekly Cost. (Average.)	Weekly Mileage. (Average.)	Daily Standing Charges.
6 h.-p.	3—5 cwts.	£185	£2 16s.	180	2s. 4d.
8—16 h.-p.	8—24 ,,	£270—290	£4 13s.	300	3s. 3d.
14—20 h.-p.	1—2 tons.	£350—600	£5—£8.	300	3s. 3d.—7s. 9d.

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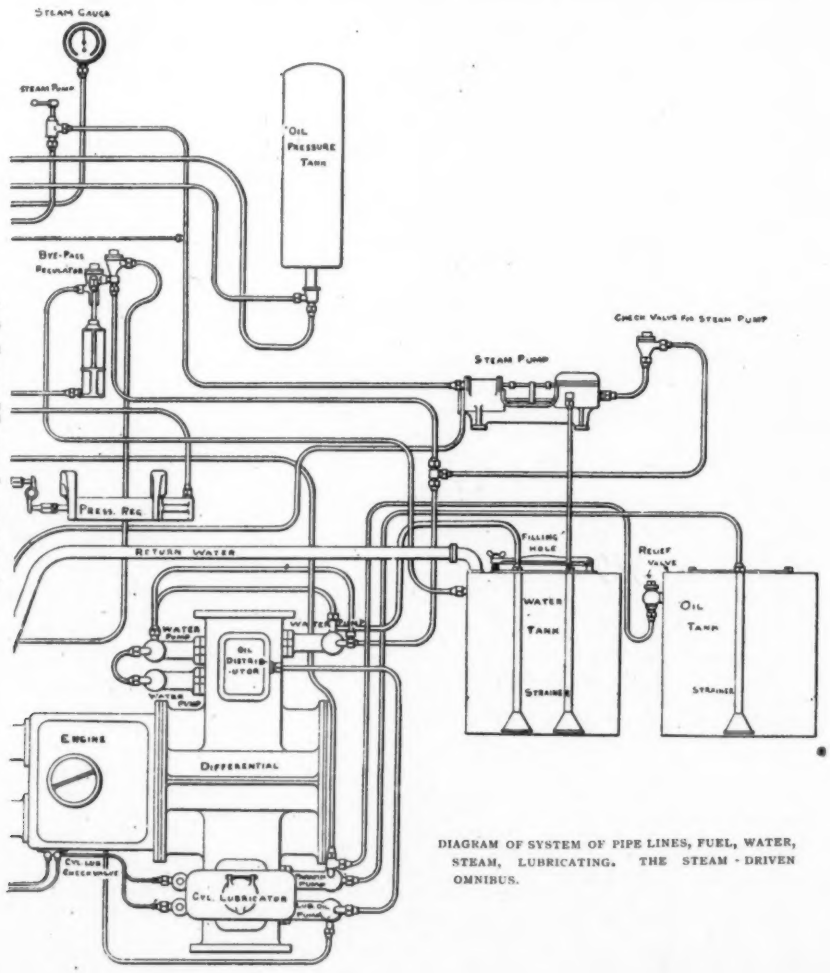


DIAGRAM OF SYSTEM OF PIPE LINES, FUEL, WATER, STEAM, LUBRICATING, THE STEAM-DRIVEN OMNIBUS.

The Steam-Driven Omnibus.

In view of the struggle for supremacy that is now being waged on the London streets between petrol and steam-driven public vehicles, the information imparted by Mr. Thomas Clarkson, M.I.Mech.E., in a recent paper given by him before the Institution of Mechanical Engineers, concerning the method of harnessing steam for public service, will be found of peculiar interest. In the course of a brief service of the history of steam vehicles on common roads, Mr. Clarkson states that it was not until 1905 that the first steam omnibus of his construction commenced regular service in London, and at present there are about forty regularly running. The principal engineering difficulty has occurred in realising to the full the advantages which unquestionably belong to the use of steam, such as freedom from noise and vibration; quick acceleration without jerkiness; flexibility of drive and simplicity of control; large reserve power for hills and for overcoming the inertia of starting; entire absence of change-speed gears; entire absence of electric ignition; and entire absence of friction-clutch.

The usual methods for the generation of steam are characterised by smoke, dirt, sparks, ashes, almost constant attention to the water-feed and to stoking, trouble from priming, from incrustation, and from leakage. To produce a generator free from the above vices, and which is regular and reliable in action, has proved a most serious problem, and it is surprising to many engineers to find that steam can be generated automatically as required without any of the preceding drawbacks.

The general arrangement of the Clarkson automatic steam generator is shown in Fig.1, the burner and oil supply details being given in Fig. 2. The burner is constructed upon the principle of supplying paraffin under a constant pressure to a vaporiser, in which it is transformed from the liquid to the gaseous state. The oil vapour is then mixed with air—on the Bunsen principle—before ignition takes place, and the heat generated by the combustion maintains the temperature of the vaporiser, chiefly by radiant effect.

The main fuel supply is carried in a tank which is not subjected to pressure. It can therefore be replenished quickly at any time without extinguishing the burner. The paraffin is pumped from the main tank into a pressure tank of solid-drawn steel, which

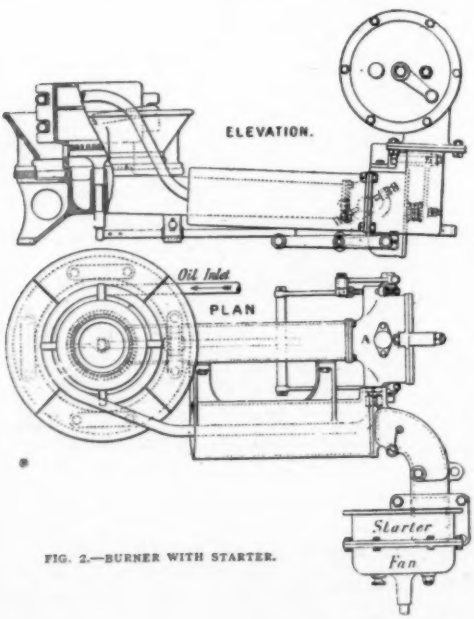


FIG. 2.—BURNER WITH STARTER.

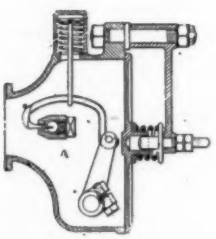


FIG. 3.—ENLARGED DRAWING OF BELL-MOUTH A, SHOWING NEEDLE VALVE AND AIR DAMPER.

THE STEAM-DRIVEN OMNIBUS.

is about half full of air. This forms a cushion which equalises the flow, and keeps the burner fed when the car is standing and the pump not delivering oil. The surplus oil delivered by the pump escapes through a spring-loaded relief valve set to about 40 lbs. pressure per sq. in., and returns thence to the main tank. To prevent loss of pressure by leakage through the relief valve when standing, a lock-up valve is provided, which, when closed and the burner out of use, will retain the pressure for long periods ready for the next lighting up. The air cushion in the pressure tank gradually diminishes with use, by "foaming" or absorption into the oil. It is replenished by a few strokes of a hand pump before starting each morning.

The oil supply to the burner, Fig. 2, is connected to the lower end of the vaporiser, from the upper end of which the vapour is conveyed to the jet nozzle, the area of which is regulated by a wedge-shaped needle, Fig. 3. This needle performs a dual function in assisting to keep the nozzle clear of obstruction, in addition to controlling the supply of vapour to the burner, and thus determining the size of flame and the rate of combustion. The rate of combustion is not governed on the oil supply, but on the supply of oil vapour. This is found to be more convenient in securing a proportionate admixture of air with the vapour for complete combustion at all rates of consumption, from the minimum to the maximum, and at all intermediate rates of consumption. The jet of vapour is directed along the axis of an inducing or mixing tube. One end of this tube is open to the atmosphere when running, and the other delivers the mixture of vapour and air into the centre or body of the burner, in which a small pressure is maintained by the force of the vapour jet. This in turn is derived from the pressure of oil in the supply tank. It follows that this pressure must be maintained practically constant to ensure regular results in the working of the burner. The mixture of vapour and air is permitted to escape from the body of the burner through a series of circumferential slots or ports, similar to the openings in a piston valve liner. The degree of opening of the ports is controlled by a piston valve moving freely inside the body, the valve being carried upon a central stem.

It will be noted that the port area varies in arithmetical ratio, and that the addition of each one-thirty-second to the stroke of the valve increases the area of the opening by an equal amount. It is necessary also to ensure, for the correct working of the burner, that the supply of vapour to the inducing tube shall also be varied in a corresponding ratio. To obtain a supply of vapour in arithmetical ratio it is necessary to form the jet nozzle either square or rectangular in shape, and to control the opening by a wedge-shaped needle having parallel sides which fit accurately into the nozzle. It will thus be noted that, as the wedge is introduced or withdrawn from the orifice, the area is diminished or increased in one dimension instead of in two, as would be the case with a circular orifice. This method of varying the area for the escape of the fuel mixture in strict accordance and simultaneously with the supply of vapour to the burner, overcame the serious difficulty of "back-firing" or "lighting back." The simple explanation is that the velocity of efflux of the vapour mixture is maintained always in excess of the velocity of the propagation of flame. Hence the flame is kept outside of the burner body.

The subdivision of the mixture, obtained by delivering it through the ports, facilitates the access of air to the flame by providing a number of air passages. The method of breaking up the flame possesses the important advantage of reducing the noise. Originally six ports were used. Better results are now obtained by employing thirty. The flame, which is in the form of a basin, is received and steadied by a conical frustrum which becomes incandescent. This shelters the flame from irregularities in the air supply, and its radiant heat is focussed upon the vaporiser, which is located within the hollow of the flame.

It is important to maintain the temperature of the vaporising coil as evenly as possible to ensure that the vapour is supplied to the burner at a fairly constant density. This has an important bearing upon the character of the flame, and the regularity of the work. A cooler vaporiser produces dense vapour which readily condenses, and which, by mixing the fuel mixture, tends to the production of a luminous flame. If the vaporiser be cooled excessively, smoke and flooding may result. When the vaporiser is heated too strongly the superheated vapour, being more highly expanded or attenuated, reduces the richness of the mixture, and tends to the production of a reddish flame and great local intensity. The total heating power of the burner is also reduced by unduly superheating the vapour, owing to the reduced weight of vapour escaping through the nozzle. The lighting-back tendency is also developed, and the vaporiser may soon

become fouled by carbon deposit obtained by dissociation of the vapour. Excessive local heating of the vaporiser means unsteady work, or "surging," coupled with local interior fouling and exterior oxidation. It is preferable to make the vaporiser with a regular slope upwards from the point where the paraffin enters to the highest part, whence the vapour is conveyed to the jet-nozzle.

Starting up.—All that is necessary is to heat the vaporiser to the working temperature, to turn on the oil-supply and apply a light to the mixture of vapour and air as soon as it appears. The preliminary heating can now be done in one minute by the employment of paraffin, and the heat is

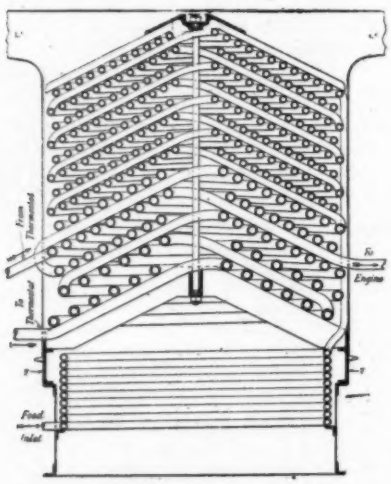


FIG. 4.—ARRANGEMENT OF 30-INCH SEMI-FLASH BOILER.

obtained in the following manner: A cast-iron box, called the starter-box, contains several asbestos wicks which are saturated with paraffin, and which readily ignite from a match. A current of air is blown from a fan into one side of the box. Through the other side of the box a strong flame is driven, which is directed through a tube surrounding the straight part of the vaporiser. The end of the flame is directed against the body of the burner, and in close proximity to the ports, so as to promptly ignite the vapour mixture as soon as it comes through. This arrangement will start the main burner in fifty seconds, and the omnibus can move by its own steam in ten minutes from "all cold."

Boiler.—The boiler is constructed wholly of water tubes. These are disposed so as to absorb the maximum heat from the products of combustion before the latter are allowed to escape, by employing the regenerative principle. That is, the general direction of the water through the boiler is opposite to that of the hot gases. The tubes nearest the fire are maintained at a fairly constant temperature by the employment of a thermostat, and the regulation of the water feed is governed directly by the pressure of steam generated. A water gauge is unnecessary, and joints are not exposed to the hot gases. Fig. 4 is a vertical section of the semi-flash boiler which is composed of thirteen elements or conical coils of tube, involute in plan, and enclosed by a cylindrical casing. The alternate coils are moved round half a revolution in assembling, which has the effect of staggering the spirals and so breaking up the gases during their passage among the tubes. The coils are bolted to a conical steel frame which rests upon the main frame *F*. Beneath *F* is secured a cylindrical fire-box, the upper part of which is lined with a coil of close wound tube. This forms a water-lagging to the fire-box, and, besides preserving it from injury, has the incidental advantage of warming the feed water before it enters the generator. From the upper end of the feed coil the water is transferred to the topmost coil of the generator, through which it circulates from the outer edge, rising towards the apex of the cone. The water then passes to the outer edge of the coil immediately below, and so on to the one nearest the fire, with the exception that it passes by or skips over coil No. 4 from the bottom.

The conical formation of the coils is a very important matter in providing effective means for retaining the contents of the generator in place. Thus, in the upper part of the generator the tubes are filled with water, but as the water descends and commences to evaporate, the tubes become charged with a mixture of steam and water, in which gradually the steam preponderates. In the lowest coil there is practically no water. This is the natural arrangement of the contents of the generator when running. On closing the throttle and stopping the circulation through the generator, the steam in the lower coils would naturally rise into the upper, thus allowing the water to descend and come in contact with the hotter tubes, in this way making more steam at a time when it was not required. The conical shape of the coil prevents this by providing a trap or lock, which Mr. Clarkson has named a "steam ratchet." The steam in each conical

element can only rise into the centre part or apex, and the water gravitates to the outer edge. There they remain until circulation recommences on the opening of the throttle. From the apex of the lowest coil the steam passes through a thermo-governor, and thence into coil No. 4, which forms a reserve immediately behind the throttle-valve.

The products of combustion are allowed to escape either by a chimney (up draught) in the case of single-deck omnibuses, or by lateral openings, L^1 and L^2 (side draught), in the case of double-deck omnibuses.

Fire Control.—It must be understood that the full power of the burner is in excess of the maximum demands for heat, and the fierceness of the flame is continually kept in check by the governor, in a manner analogous to the action of a steam engine governor. The main principle governing the fire control is the maintenance of an equable temperature in the steam which is generated; in other words, *the supply of heat to the generator is governed by the temperature of the steam generated*. The steam is delivered from the generator in a superheated state, and from 700° F. to 800° F. is found to be a convenient temperature. The employment of highly superheated steam is essential for economical working.

In order to employ the temperature of steam as a governing factor, the most effective control of the fire is secured by the combined action of temperature and pressure. The temperature is the main factor when *running*, and the pressure when *standing*. The employment of pressure is really a conversion of thermal effect to meet the special circumstances of the case, and, speaking broadly, the control of the fire is due to the *temperature* of the generator and its contents.

Water Control. — The automatic water control of the generator is in the form of a by-pass regulated by the steam pressure. The pumps are always taking the full charge of water, which is either delivered into the generator, or allowed to return to the tank should the by-pass be open. There is no intermediate condition. The construction of the by-pass regulator is shown in Fig. 5, in which *A* is a spring-loaded piston which is subject to the steam pressure acting through the water of condensation which fills the connecting pipe. The feed water is forced in at the connection *C*, and must all enter the boiler through the check-valve *V*, until the steam-pressure is pumped up sufficiently to open the by-pass by the action of the steam pressure upon the piston *A*. It will be noted that the piston *A* has to be forced against the load of the spring *S*, and as soon as the centre rod touches the stem of the mushroom valve *M* an increased resistance is encountered, due to the pressure of water upon the top of the mushroom valve. There is also a slight extra resistance from the return spring *SI*. There is a slight pause until sufficient pressure has accumulated to overcome this increased resistance, when instantly the valve is opened the water pressure upon the top of the valve disappears. This load having to be carried by the main spring *S*, the latter suffers a further compression which causes a little

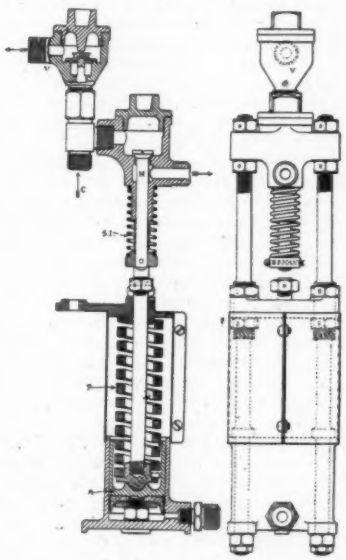


FIG. 5.—FEED-WATER REGULATOR OR BY-PASS.

jump in the lift of the valve. The advantage of this is to lift the valve quite clear of its seating ($\frac{1}{8}$ in.), thus permitting a free passage for the water back to the tank. This very simple arrangement also avoids risk of fouling, as would result from a partial opening. It will also be noted that when the pumps are not delivering into the generator they are absorbing practically none of the engine power, as the water is merely circulating through an unrestricted passage in which the friction is very small.

Thermo-Governor or Fire Control Gear.—The steam from the apex of the lowest coil of the generator is led immediately into the expanding tube *E* (Fig. 6), one end of which

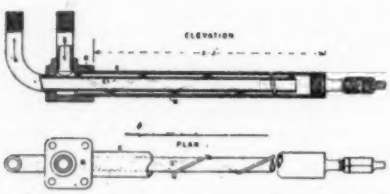


FIG. 6.—THERMO-GOVERNOR WORKING IN CONNECTION WITH FIG. 7.

is rigidly secured to the clamping block *B*, and the other end of *E* is plugged, the centre of the plug carrying an extension or stud which moves the burner control gear. Inside the tube *E* is a smaller tube E^1, also secured to the clamping block *B*, and passing directly through it, whence it is connected to coil No. 4. The other end of the tube E^1 is left open and reaches almost to the plug in the end of *E*. The inner tube E^1 is secured concentrically with the tube *E* by the wire spiral *W*, which also secures the advantage of distributing the steam evenly between the two tubes and so ensuring uniform heating. The clamping block *B* is securely bolted to one side of the main frame, and the other or free end of the tube *E* is supported in a bracket also attached to the frame, through which it can slide freely as its length changes owing to variations in the temperature of the steam passing through it. It will be noted that the whole of this thermo-governor is constructed of steel.

A movement of about $\frac{5}{16}$ in. is obtained in the free end of the tube *E* between normal temperature of the atmosphere—say 60° F.—and the working temperature of the generator. This endwise movement is translated directly to the burner-control gear (Fig. 1). This form of governor is found to be quite effective for preventing an undue rise of temperature in the generator, so long as the steam within the generator is allowed to circulate; but when the circulation ceases—as on closing the throttle—the thermostat gradually loses heat by radiation, although well lagged, and in a short time would cause the burner flame to be increased. The further heat thus supplied to the generator would have little or no effect upon the thermostat, seeing that the latter is entirely outside the fire-box. It is therefore necessary, as indicated above, to employ other means for preventing the addition of heat to the generator when the circulation of steam is stopped. Accordingly a spring-loaded piston (Fig. 7) is arranged to turn down the supply of heat as soon as the pressure within the generator exceeds normal limits.

The immediate effect of shutting-off steam to bring the car to rest is to cause an increment of pressure by the momentum of generation, which speedily brings the supplementary cylinder into action. It is found in practice that, before the omnibus has come to rest, the burner has been shut down to the minimum flame.

Conversely, when starting again the immediate effect of opening the throttle is to cause a reduction in pressure, which is responded to by the supplementary cylinder withdrawing and allowing the fire control to be regulated by the thermostat.

The rock shaft (Fig. 1), situated between the thermostat and the pressure regulator, is fitted with a double lever which is pushed on the one side by the thermostat (Fig. 6), and on the other side by the supplementary cylinder (Fig. 7). This forms an extremely simple and convenient arrangement for the interchangeable action of the dual system of control. The rock shaft is directly connected by a coupling rod to the burner control, the said coupling rod being provided with a spring dash pot, which allows an increase in the length of the coupler in the event of a slight overrun on the part of the governors, thus avoiding strain and deformation of the gear.

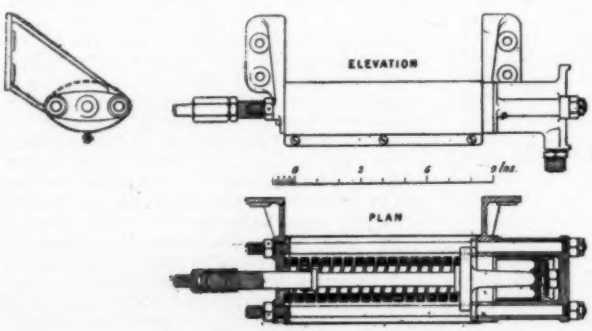


FIG. 7.—PRESSURE REGULATOR

The evaporative efficiency of this generator was tested in the following manner:—The burner was adjusted to consume 50 lbs. of oil per hour at a uniform rate. Over the burner were placed

successively 1, 2, 3, 5, 7, 9 and 12 elements. Water was fed downwards through the elements at a rate sufficient to maintain a pressure of 300 lbs. per sq. in. The throttle opening was adjusted to maintain the temperature (of superheat) at 800° F. The results are plotted in Fig. 8.

An air condenser is placed in front of the chassis, thus having the advantage of fresh air which is circulated through the condenser by a propeller fan. The engine is between the generator and the rear driving axle. The cylinders lie horizontally and forward of the engine. The engine gear is completely enclosed, and the motion is transmitted from the crank shaft to the differential by spur gear in the reduced ratio of 3 to 1. The differential gear (Fig. 9) is of the spur type, which is preferred to the bevel type on the score of simplicity and the elimination of end thrust. The two halves of the differential shaft carry the eccentrics for actuating the pumps, and to the outer ends of the differential shafts are fitted brake drums, and also the chain sprockets through which the power is transmitted direct to the road wheels. Particular attention is drawn to the fact that no change gears or disengaging clutches are employed. An average gear ratio is selected between the engine and the driving wheels of such proportion that the omnibus can easily ascend or start up the steepest hills when fully loaded, and it also enables a speed to be obtained on the level sufficiently high for practical purposes upon a public service vehicle. This important result is obtained simply from the remarkable flexibility of the steam, and herein rests one of the greatest advantages of the system.

The importance to the driver, particularly

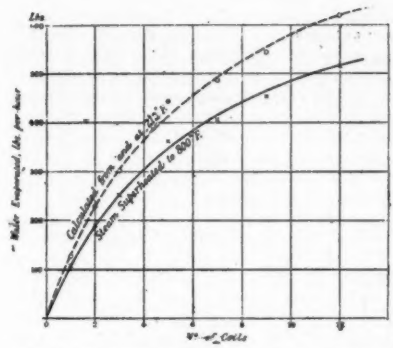


FIG. 8.—EVAPORATIVE EFFICIENCY OF GENERATOR. STEAM 'BUSES.

in crowded traffic, of a simple control, without change gear or clutch mechanism, and controlling by the one lever which controls the supply of steam, will be apparent. Added to this is the important advantage of smooth and rapid acceleration. A further advantage of the absence of gears is the silence of operation and freedom from vibration, as the engine is not moving when the car is at rest. To the rear of the driving axle the tanks for fuel and water are secured to the main frame. The filling of the tanks is done through large hoppers secured to the outside of the frame, and arranged that, in the event of any oil or water being spilled, it drops on the ground, and not upon any part of the vehicle.

Lubrication.—The general lubrication of the engine and differential gear is by a system of pump circulation combined with an automatic distributing valve (Fig. 10),

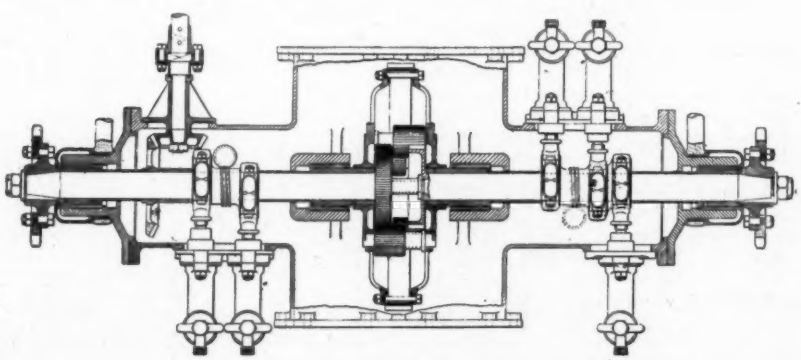


FIG. 9.—DIFFERENTIAL GEAR AND CASE, SHOWING PUMP AND CHAIN SPROCKETS.

which supplies the oil to each of the bearings successively. The engine and differential cases are combined, and a well or sump is fitted at the lowest point. Into this all the surplus oil drains from every bearing, and from the sump the oil is delivered by a force pump into a circular valve box which is connected by a pipe with every bearing of the mechanism. To provide against the possibility of any of these distributing pipes becoming fouled or obstructed, a circular valve is provided which covers up all the outlets of the distributing pipes with the exception of one. This one has therefore to take the whole of the oil which is delivered by the pump. The distributing valve is slowly rotated by a worm gear on the differential shaft, and so the delivery of oil is automatically transferred from one bearing to another, and the possibility of a stoppage is avoided. It naturally happens that some of the distributing pipes are much longer than others—depending upon the distance of the distributor from each of the bearings. This, however, does not reduce the quantity of the oil supplied, even to the most distant bearing, but when the longest pipe is switched on to the pump the latter absorbs a little more power in forcing the same quantity of oil through the longer pipe. The system has the important advantage of taking out of the hands of the driver the responsibility for attention to lubrication, particularly for the high-speed mechanism. Also, the lubrication commences and ceases simultaneously with the running of the mechanism.

Cylinder Lubrication.—The result of Mr. Clarkson's experience has led him to adopt a system of force pump feed, and the general arrangement of the cylinder lubrication is shown on Fig. 11. In this drawing it will be noted that an aluminium box, which forms the reservoir for cylinder oil, also contains two pumps, the plungers of

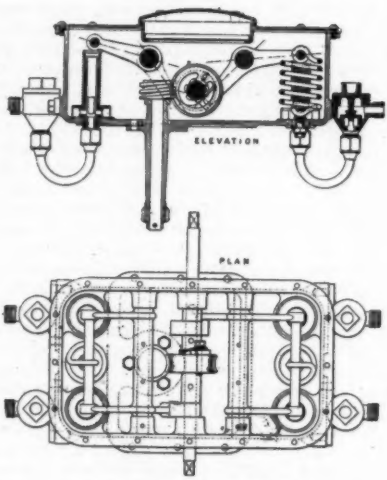


FIG. 11.—CYLINDER LUBRICATOR.

which are forced down sharply at regular intervals by a cam-operated spring. There is no packing of any kind in the pumps, but the plungers are made a good fit. After the cylinder lubricator has been charged, no further attention to cylinder lubrication

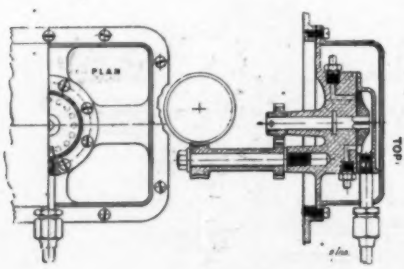


FIG. 10.—ASSEMBLY OF OIL DISTRIBUTOR.

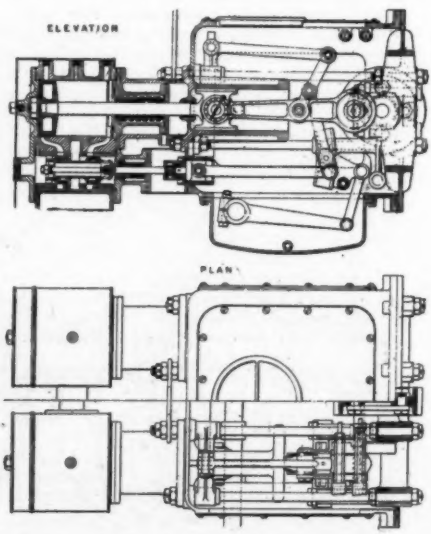


FIG. 12.—ENGINE.

is necessary for 1,000 miles. This also has a great advantage in securing regularity of working, and is again quite outside the sphere of the driver. It merely requires periodical inspection and replenishment from the engineer in charge of the garage. The oil is introduced into the steam pipe close to the engine, and is carried through with the exhaust into the condenser, from which it returns back into the water tank. Previously a filter was provided to separate this oil from the water of condensation. which is used again for boiler feed. This, however, has been found unnecessary, and the oil is allowed to collect upon the surface of the water, from which it may be skimmed at the end of each day. This skimmed oil is saved, and is found to answer extremely well for lubrication of other parts, such as chains, hubs, steering gear, &c. This oil may also be used again for cylinder lubrication after filtration.

General Arrangement of Engine (Fig. 12). —The engine has two horizontal double-acting cylinders 4 ins. diameter by 4 ins. stroke, which are in two separate castings with a view to prevent distortion by the employment of highly superheated steam. The cylinders are attached to distance pieces bolted to the outside of the aluminium gear box, which contains all the motion. It is found convenient to place the valves for the distribution of the steam beneath the cylinders, as this dispenses with the necessity for the employment of drain cocks. The water readily gets away through the exhaust immediately the port is opened.

The valves are of the piston type, fitted with rings, and are actuated by "Joy" gear. This enables a very simple form of crank shaft to be employed, which is built up of two parts, each forged out of the solid, and bolted together with a steel spur wheel in the centre. The cranks are at right angles, and the crank shaft is hardened and ground on both the journal and the crank pins.

Correspondence.

To the Editor *Engineering Review*.

Dear Sir,—I notice that your leading article in the August number of the Engineering Review concerns the Salisbury disaster, a review of the possible causes or cause of the derailment being therein dealt with.

As a practical railway man, I would like to say there is little doubt that the cause was insufficient super-elevation of the outer rail.

On a curve of 528 ft. radius, speed, as you say, should never exceed 30 miles per hour, and the correct super-elevation for this speed is 5½ ins., whereas the curve in question had only 3½ ins. If I were the Board of Trade Inspector I should require to know why, and under what conditions, only 3½ ins. super-elevation could be given.

The person who allowed a curve of 528 ft. radius to be unchecked, as I understand this was, and to remain on a main line, with only the super-elevation mentioned, should be called upon to explain why such conditions were allowed.

I have at the present moment under my charge eleven curves of similar radius, and the minimum super-elevation for the speed of 30 miles per hour is 4¾ ins., and this on a 3-ft. 6-in. road. The curves, with this cant even, are situated on the apex of two grades; where such curves occur at the bottom of a grade the cant is increased to 5½ ins., and in practice this is found only sufficient; the curves (with particular exceptions) are also checked.

The following roads use 5½ ins. cant for a speed of 30 miles per hour: Illinois Central, Louisville & Nashville, Northern Pacific, H. & H. Pacific, N. Y. N. Southern, the gauge being 4 ft. 8½ ins.

Yours truly,

Permanent Way Inspector.

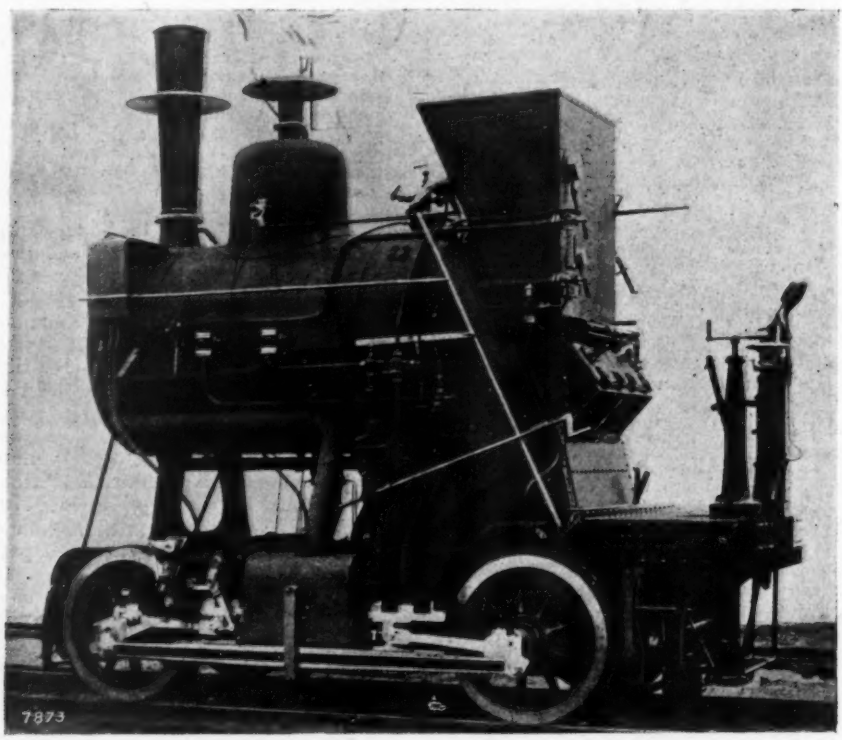
Locomotive and Railway Engineering.

By C. EDGAR ALLEN.

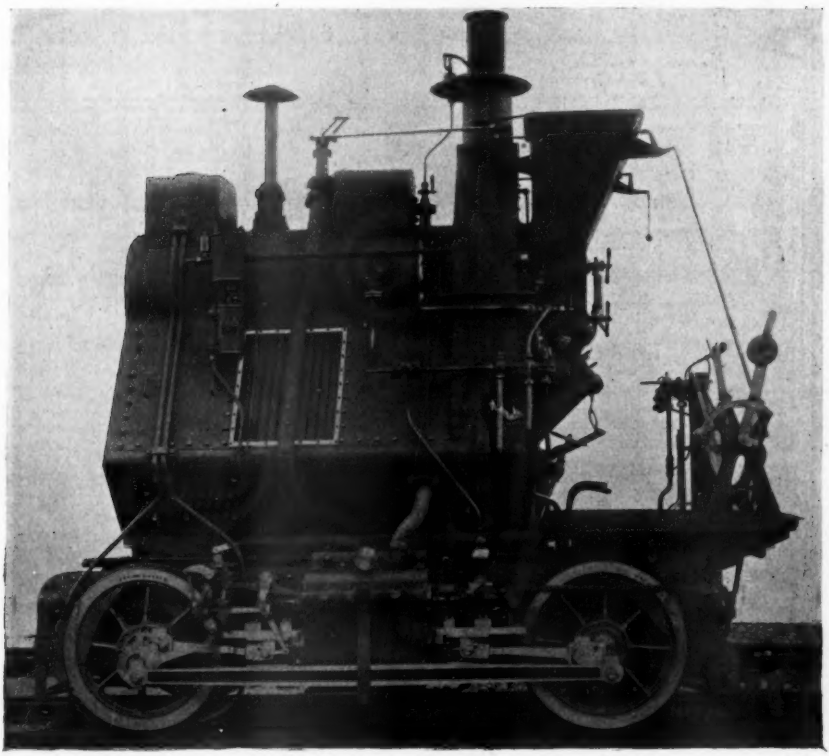
Motor Coach Engine, Bavarian State Railways.

Engines of interesting design constructed for railway motor service on the Bavarian State Railways by Messrs. J. A. Maffei, Munich, are illustrated in the accompanying half-tones.

Both engines, which are carried on a bogie independent of the carriage frame, have two cylinders, each of 200 mm. dia. and 2 by 260 mm. stroke, one on each side of the bogie frame. In each cylinder is the unusual arrangement of two pistons, each driving through a crosshead and connecting rod, on a pair of the bogie wheels of 990 mm. dia., all of which latter are thus driven. The cranks are set at 90 degs., thus ensuring a more even turning moment than is the case with only two cylinders, and reducing lateral oscillation to a minimum. Smoothness of running is further contributed to by



RAILWAY MOTOR COACH ENGINE, BAVARIAN STATE RAILWAYS.



MOTOR COACH ENGINE, BAVARIAN STATE RAILWAYS.

the fact that leading and rear pairs of driving wheels are coupled by a massive coupling rod milled to a channel section. The normal working pressure is 255 lbs. per sq. in., and steam distribution is effected by piston valves driven by a simple modification of the "Walschaerts" gear.

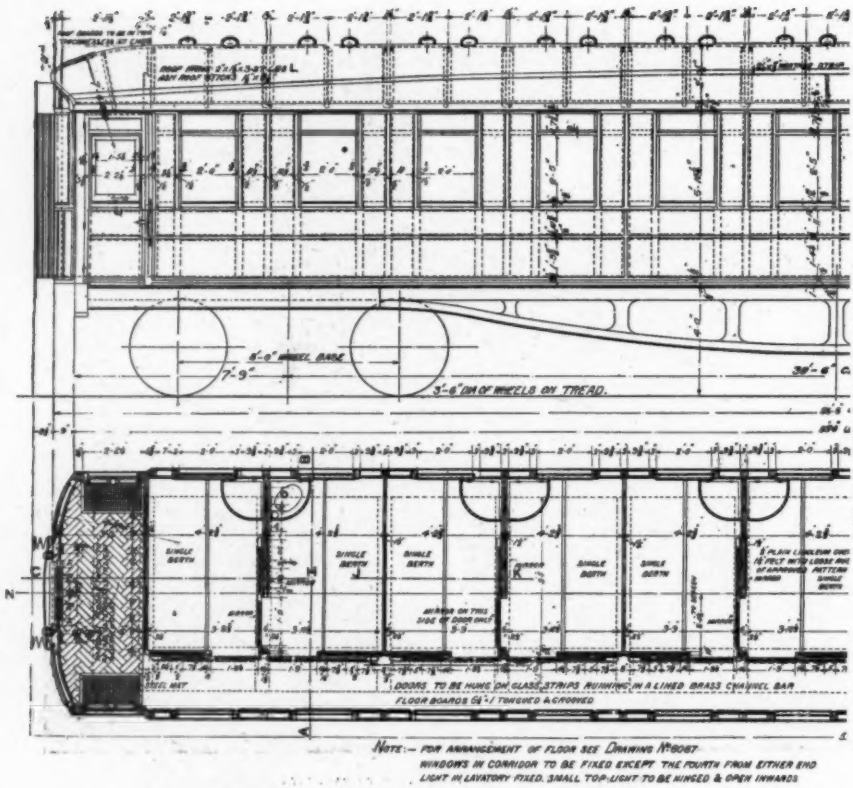
The boiler is of the locomotive type, having a total heating surface of 442 sq. ft., a superheater providing an additional 74 sq. ft. Firing is effected by means of a hopper attached to the firebox, from which the coal is fed to the fire. The maximum speed attainable is about 47 miles per hour, and the carrying capacity of the coach eighty-five persons, fifty-five seated and thirty standing.

New Sleeping Cars for East Coast Joint Stock.

As promised in our last issue, in which this interesting vehicle was fully described, we now reproduce the full drawings, with acknowledgments to Mr. Wilson Worsdell, Chief Mechanical Engineer of the North-Eastern Railway, who was responsible for the design.

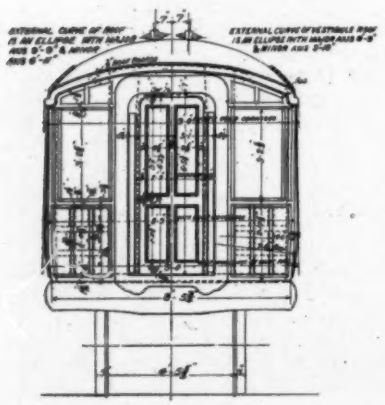
Bogie Passenger Engine, 908 Class, Caledonian Railway.

By the courtesy of Mr. J. F. McIntosh, locomotive superintendent of the Caledonian Railway, we are able to illustrate one of a new class of engine now constructing at the St. Rollox works


6'-0" WHEEL BASE
7'-9"
3'-6" DIA OF WHEELS ON TREAD.
SINGLE BERTH
DOORS TO BE HUNG ON GLASS STRIPS RUNNING IN A LINED BRASS CHANNEL BAR
FLOOR BOARDS 5/8" TONGUED & GROOVED
NOTE:— FOR ARRANGEMENT OF FLOOR SEE DRAWING N°8087
WINDOWS IN CORRIDOR TO BE FIXED EXCEPT THE FOURTH FROM EITHER END
LIGHT IN LAVATORY FIXED, SMALL TOP-LIGHT TO BE HINGED & OPEN INWARDS

DETAILS OF SLEEPING CARRIAGE, EAST COAST JOINT STOCK.

(Continued on page opposite.)

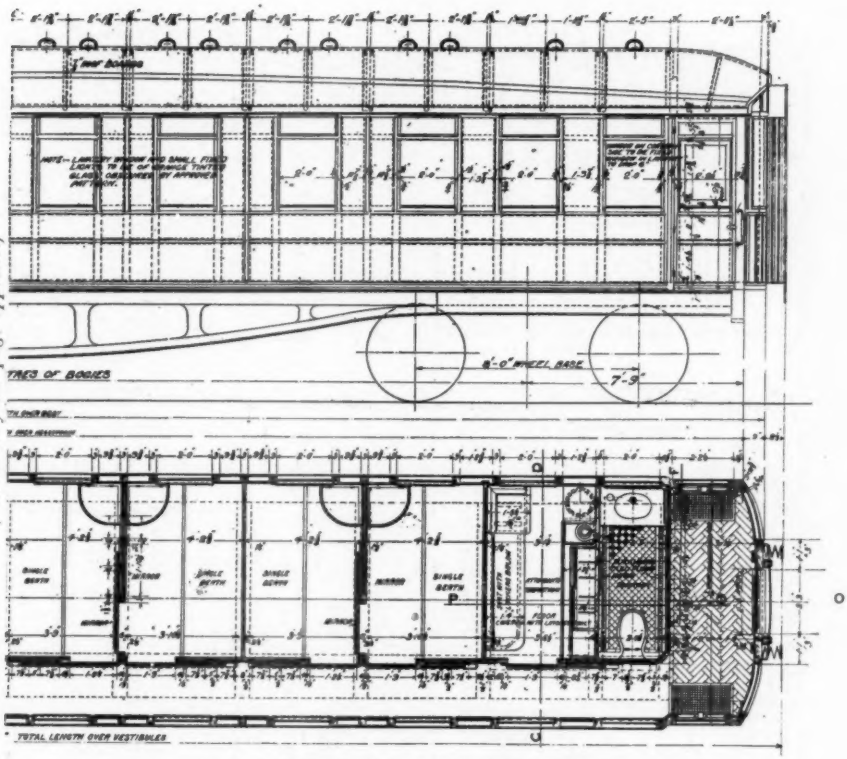


of the company, known as the "908 class." It will comprise ten locomotives, and is the third different class of engine turned out of St. Rollox this year, the others being the "903 passenger class" and "918 goods class."*

The subject of the illustration, which has been named "Sir James King" out of compliment to the chairman of directors, is of the 4-6-0 type, with inside cylinders driving on the front axle of the coupled wheels. The group of four safety valves are 4ins. in dia. with independent springs adjusted to blow off at the working pressure of 180 lbs. per sq. in.

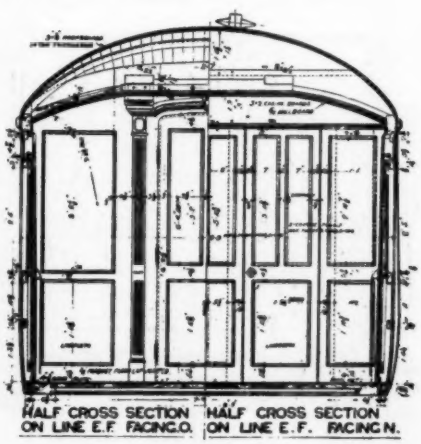
* THE ENGINEERING REVIEW, Vol. XV., pp. 131 and 294.

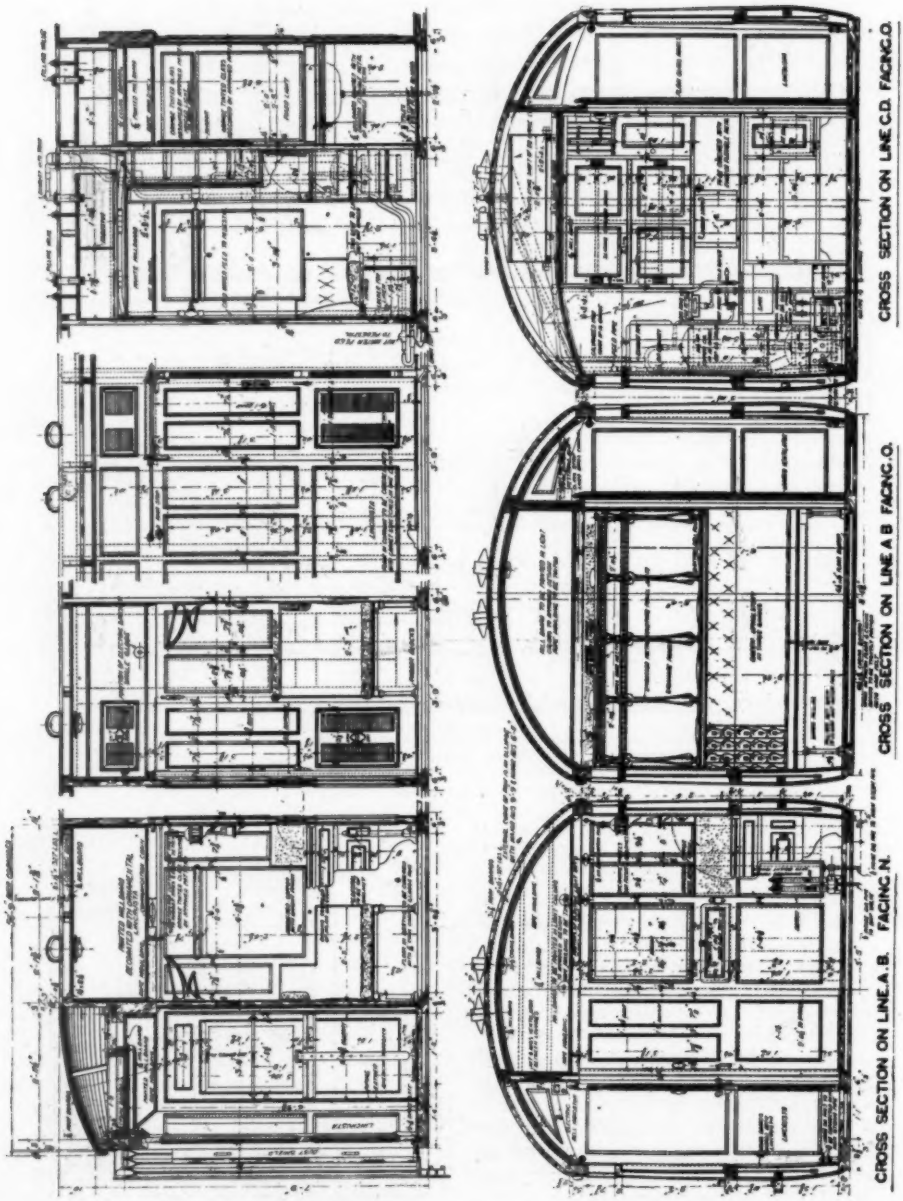
(Continued from page opposite.)



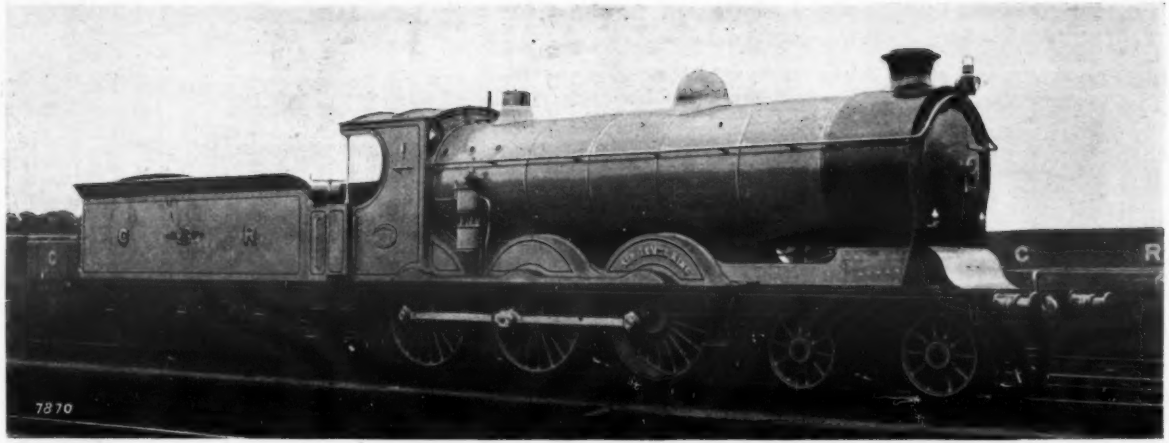
DETAILS OF SLEEPING CARRIAGE, EAST COAST JOINT STOCK.

The valve motion is the "Stephenson" link type, and steam reversing gear, coupled direct to the reversing shaft, is provided. The built crank axle has journals 9¼ ins. dia. by 7½ ins. long, and the connecting rod bearing is 9½ ins. dia. by 4 ins. long. The intermediate and trailing axles have concave journals 7¾ ins. dia. at centre by 9¼ ins. dia. at ends by 12 ins. long. To allow a total side play of ½ in. at the trailing wheels flexible coupling rods are provided. The engine is equipped with the usual Westinghouse air brake fittings complete, also with an ejector and vacuum "through" brake pipe.





DETAILS OF SLEEPING CARRIAGE, EAST COAST JOINT STOCK.



THE "SIR JAMES KING." 4-6-0 TYPE. CALEDONIAN RAILWAY.

The following are the principal dimensions :—

ENGINE.

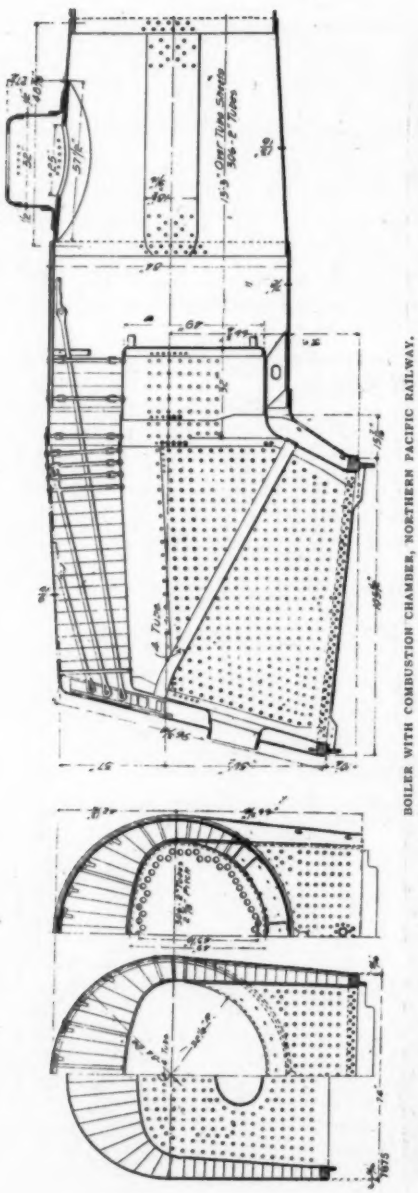
	ft.	ins.
Cylinders, diameter	1	7
,, stroke	2	2
Wheels, diameter on tread (bogie)	3	6
,, ,, ,, (coupled)	5	9
Boiler, height of centre from rail	8	6
,, length of barrel	15	$8\frac{3}{16}$
,, diameter of barrel	5	$3\frac{1}{2}$
,, thickness of barrel plates		$\frac{21}{32}$
Firebox shell, length outside	6	11
,, ,, breadth at bottom	4	0
,, ,, depth from centre at front	5	0
,, ,, depth from centre at back	4	3
,, ,, thickness of plates, sides		$\frac{25}{32}$
,, ,, thickness of plates, crown		$\frac{25}{64}$

	ft.	ins.
Tubes (mild steel), number, 242.		
,, ,, ,, external diameter		2
,, distance between tube plates	14	$11\frac{7}{16}$
,, height of chimney above rail	12	11
	sq. ft.	
Heating surfaces, firebox	128	
,, ,, tubes	2,050	
Total	2,178	

Grate area, 21 sq. ft.
Working pressure, 180 lbs. per sq. in.
Weight of engine in working order, 64 tons.

TENDER.

Capacity of tanks, 3,570 gallons. Fuel space, $4\frac{1}{2}$ tons.
Diameter of wheels, 4 ft. Weight of tender, full, 38 tons.
Weight of engine and tender in working order, 102 tons.
Length of engine and tender over buffers, 58 ft. 11 ins.



BOILER WITH COMBUSTION CHAMBER, NORTHERN PACIFIC RAILWAY.

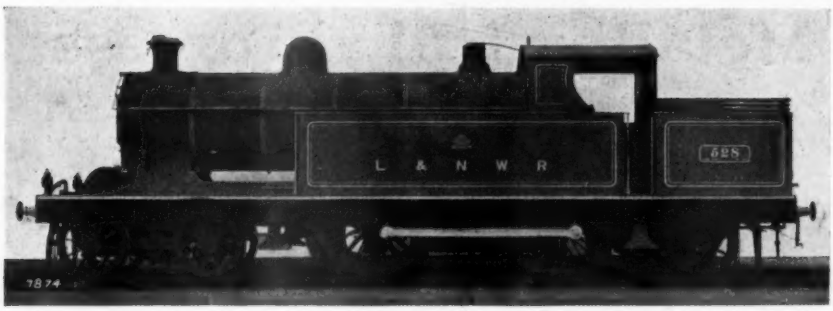
Combustion Chambers for Locomotives.

Mr. David Van Alstyne, mechanical superintendent of the Northern Pacific Railway, has for some time past been engaged in testing the value of a combustion chamber on one of the Mikado type locomotives of his company using soft coal, with such eminently satisfactory results that he has specified combustion chambers on all of an order of 70 locomotives just placed with the American Locomotive Company. The locomotive so fitted was put into service in 1905, and has since been operated on several divisions of the line when boiler troubles were the most numerous and water conditions the worst.

The introduction of the combustion chamber reduced the amount of tube heating surface from 3,798 sq. ft. to 3,192 sq. ft., or 16 per cent., and increased the fire-box heating surface from 209 sq. ft. to 245 sq. ft., equivalent to a reduction in the total heating surface of from 4,007 sq. ft. to 3,437 sq. ft.

In spite of this fact it was found that the steaming capacity of this engine was equal to that of engines of similar type not fitted with the combustion chamber, and that much less work was required on the tubes. Further, what work was necessary on the tubes could be done without removing the brick arch. It was also found that no cinders had collected in the combustion chamber and that the tubes were all open.

The general construction and arrangement of the combustion chamber can be seen by reference to the illustration. The ring forming the chamber is radially stayed from the boiler shell on the upper section, and is supported and stiffened by specially designed plates set longitudinally between it and the shell at the bottom and part way up the sides. The chamber has a clearance for circulation of 7½ ins. at the bottom, narrowing to 7 ins. at the closest point at the sides, which, according to the *American Engineer & Railroad Journal*, will probably prove to be sufficient to furnish the required circulation for the firebox



4-4-2 CLASS PASSENGER TANK ENGINE, L. & N. W. RAILWAY.

side sheets and back head. The inner throat sheet meets the combustion chamber ring in a curve of long radius, and the brick arch occupies its usual position from the throat sheet diagonally upward.

The provision of a combustion chamber in locomotive boilers is not altogether a new departure, as the late Mr. F. W. Webb had some of his three-cylinder compounds so fitted.

4-4-2 Class Passenger Tank Engine, L. & N. W. Railway.

A number of bogie tank engines built to the designs of Mr. G. Whale, locomotive superintendent, have recently been completed at the Crewe works of the L. & N. W. Railway Company, and are now hauling heavy suburban trains between Manchester and Buxton and Euston and Tring. As will be gathered from the illustration and list of dimensions, they are of heavy type, and rank as the largest in this country. The leading end of the engine is carried on a radial truck, which, in addition to the turning motion of the ordinary truck, has a side play of 1 in., this combined movement allowing greater freedom when going round curves. The trailing end is carried on a radial truck which has a side play of $1\frac{7}{8}$ ins. The cylinders are 19 ins. diameter by 26 ins. stroke; the balanced valves being worked by Joy's motion. The leading dimensions are as under :—

Diameter of cylinders, 19 ins.
Piston stroke, 26 ins.
Boiler, mean outside diameter, 5 ft. $\frac{3}{4}$ in.
,, length of barrel, 11 ft. $7\frac{5}{8}$ ins.
,, length between tube plates, 12 ft. $\frac{3}{8}$ in.
,, working pressure, 175 lbs.
Fire-box, length outside, 7 ft. 4 ins.
,, width outside, 4 ft. 1 in.
Heating surface, tubes, 1,777·5 sq. ft.
,, ,, firebox, 161·5 sq. ft.
,, ,, total, 1,939 sq. ft.
Grate area, 22·4 sq. ft.
Water capacity of tanks, 1,700 gallons.
Coal capacity, 2 tons 10 cwts.
Wheels, radial truck, 3 ft. 9 ins. diam.
,, driving and coupled, 6 ft. 3 ins. diam.
,, trailing (radial), 3 ft. 9 ins.
Wheel base, centre of truck to driving wheel, 12 ft.
,, ,, centre of driving wheel to coupled wheel, 10 ft.
,, ,, centre of coupled to trailing wheel, 7 ft. 6 ins.
,, ,, total, 32 ft. $7\frac{1}{2}$ ins.

Weight of engine in working order—

	Tons.	Cwts.
On radial truck	21	5
,, driving wheels	19	15
,, coupled wheels	19	15
,, trailing wheels	14	0
Total	74	15

Metallurgical Progress.

By PERCY LONGMUIR.

FOUNDRY PRACTICE.

Saving Floor Space.—In the current issue of *The Foundry* Mr. H. J. McCaslin gives a good example of composite or multiple moulding as a means of saving floor space. As a case in point, a circular ring of the section shown in Fig. 1, and 12 ft. in diameter, is selected. Suitable core boxes are made to form the lower and top faces of each ring, top and bottom cores fitting together by means of male and female joints in order to locate them in position one upon the other. In building up the mould a pit is sunk and a level bed struck from a spindle as in Fig. 2. The method of setting the lower cores is also shown in Fig. 2, and it will be noted that the gauge stick *A* ensures a circle of the right diameter being formed. The covering cores are placed in position and a light bed of sand swept over them to receive the lower cores for the second ring. This is continued until cores have been set to form three separate moulds. The runner is centrally located and each ring receives metal from four gates placed at right angles to one another as shown in Fig. 3, which illustrates two half sections of the mould, the section at the right being taken through the gates illustrating the manner of gating, whilst the section at the left shows the method of attaching risers. Runner and gate cores are shown in detail in the upper part of Fig. 3, and also in position in the lower part of the figure. After the first set of cores for the gates are placed in position, the first one of the block cores for the runner is placed in the centre and the sand backing rammed until the openings for the second series of cores are reached, when the gate cores and the next block for the runner core are set as in the first case. When the backing of sand reaches the top of the upper series of cores a level bed is struck off to receive the holding down plates. The risers are formed by the use of the riser block shown in Fig. 3. Runners and risers are then carried up to the desired height and the cores weighted down for casting.

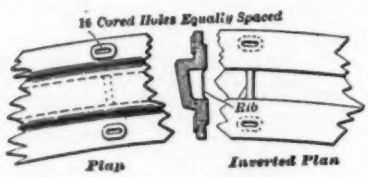


FIG. 1.

Converter Steel Castings Practice.—In the October issue of *The Foundry* Mr. A. Simonson gives the first instalment of a series of articles on "Tropenas" steel-making practice for castings. The mechanical side is first considered, and a plant consisting of one two-ton converter having a capacity of about 40 tons of castings per week is considered. Such a plant would consist of converter, converter blower, and motor cupola, cupola platform and hoist, cupola blower and motor, ladles and ladle-heating plant. The shell of the converter is 5 ft. in diameter, and is made from $\frac{1}{4}$ in. steel plate perforated with $\frac{3}{4}$ in. holes spaced 8 ins. centre to centre, to allow of the escape of steam when drying the lining. The floor space occupied by the converter is about 16 sq. ft. and the head room required is from 18 to 20 ft., in order that the whole of the flame may

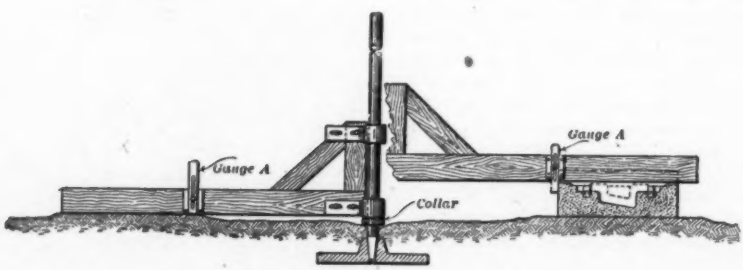


FIG. 2.

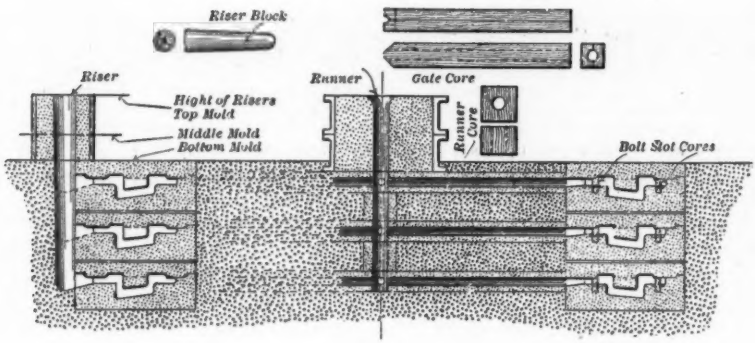


FIG. 3.

be visible at all times. The converter is supported on steel trunnions, one of which is hollow and forms a duct for the air, connecting with the blast box at the back of the converter. The blast box is a double one, and air can be admitted to either one separately, or in varying proportions. This is partly shown in Fig. 4, which is a section of the converter both horizontal and vertical, showing the arrangement of the tuyeres, the level of the bath, and the approximate position of the vessel while the blow is being made. The other trunnion is extended, and carries a worm wheel which through suitable gearing is connected to a 4 h.-p. motor. A hand wheel is also provided for making small movements of the vessel. The height of the converter should be such as to permit a complete revolution, which will enable the whole of the metal to be poured out before the vessel is too low for ladles to be held under it. The covers of the blast boxes are fastened on by means of keys for quick removal in order to clean out a tuyere or to set the converter at the beginning of a blow. The upper box is fitted with a pipe having an independent valve so that it may be shut off entirely if desired, or any required amount of blast admitted.

The particular type of cupola for the "Tropenas" converter is largely a matter of opinion. The cupola is required to melt about 5 tons per hour of a charge containing as much as 50 per cent. steel scrap; it must give hot metal and be capable of running long heats. Any type that will meet these conditions is suitable, but after much experience the author reaches the conclusion that a somewhat special type of cupola is the best. Practically this type is one built on the lines of a blast furnace with bustle pipe and pendant tuyeres as illustrated in Fig. 5. The bustle pipe or blast box must be of ample size in order to maintain an equal pressure at all of the six tuyeres. The advantage of this type of cupola is that the tuyeres are always clean, and that if any slag or iron runs into them it runs out again without entering the blast box. The cupola shell should be 54 ins. diameter, lined with two rows of 4½ in. bricks, giving an internal diameter of 36 ins. A slag hole is placed 6 ins. below the tuyeres, and when melting a blast pressure of from 10 to 14 ins. of water is maintained.

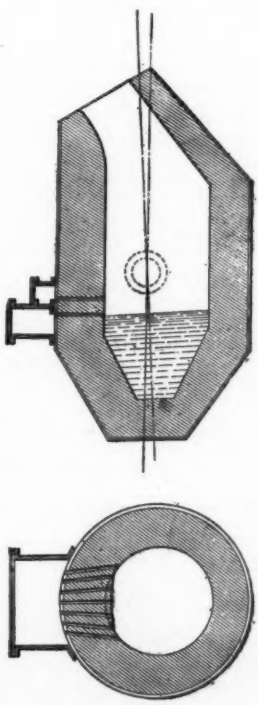


FIG. 4.

Some Methods of Measuring High Temperatures.—Mr T. Swinden, in a comprehensive paper read before the British Foundrymen's Association, clearly describes various methods of high temperature measurement. At the outset the practical value of temperature measurement to iron, steel and brass founders was indicated and illustrated by special reference to furnace temperatures, casting temperatures and the control of annealing ovens. Some typical cupola temperatures are as follows:—

Time.	Weight Tapped.	Tapping Temperature.	Casting Temperature.
4.10 p.m.	6 cwts.	1280° C.	1240° C.
4.33 ,,	11 ,,	1350°	1240°
4.40 ,,	4 ,,	1316°	1274°
4.55 ,,	5 ,,	1325°	1255°
5.00 ,,	5 ,,	1355°	1250°

These temperatures were determined by means of the "Wanner" pyrometer, an instrument which, in the author's opinion, is likely to prove of high value in foundry practice. After describing the various principles upon which pyrometers have been constructed the author passes on to a consideration of the instruments commercially available, giving the salient features of each type. Finally, in summarising the subject, it is shown that the costly and somewhat fragile resistance pyrometer, although of undoubted accuracy, is hardly a suitable instrument for foundry use The thermo-electric couple has a wider application, the accuracy, portability, and low cost being strong factors in favour of its use. Optical instruments, whilst possessing both unique advantages and disadvantages, are greatly in advance of either of the foregoing, since their application is so easy in places inaccessible to thermo-couples. The "Féry" pyrometer is a good example of an instrument capable of extremely wide application. The "Uehling" pyrometer has a special field in blast furnace practice, and the durability and sensitivity of instrument and recorder are unquestioned, the only drawback being that of high initial cost.

Some Notes on the Chemistry of Cast Iron. — This paper, read by Mr. L. Houghton before the British Foundrymen's Association, is practically a review of the influence of the various elements present in cast iron. Special attention is devoted to carbon, and to the fact that in the future it may be necessary to distinguish between graphitic carbon and temper annealing or carbon. In dealing with the influence of silicon, Outerbridge's work, recently noted in these columns, is mentioned, and some interesting tests by the author are quoted in the table below.

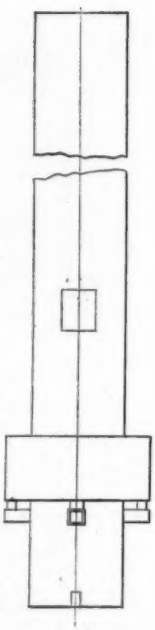


FIG. 5.

In the first two examples quoted in this table the cupola was running on a light-coloured slag, whilst the last two are from a cupola working with a dark slag. The results are interesting rather as a comment upon the statement by Mr. Outerbridge that the good results may be due to the extraction of oxygen from the metal than as decisive for or against such additions. In the first case, the iron being melted in a hot cupola on a light-coloured slag, indicating a sufficiency of coke and limestone for fluxing, the conditions are such as to retard the absorption of oxygen, whilst in the second case these conditions are absent. In the first case the addition of silicon reduces the strength and deflection, but in the second case these factors are increased, and it would seem as if there were some connection between the two. It may be that since American iron

Character of Slag.	Pure Silicon added.	Quantity of Metal used.	Transverse strength.	Deflection.	Per cent. Alteration in strength.	Per cent. Alteration in deflection.
	lb.	lbs.	lbs.			
White	¼	50	3,160	·310		
	None.		3,350	·333		
			loss 190	·023	5·7	7·0
White	½	100	3,000	·320		
	None.		3,300	·350		
			loss 300	·030	9·1	8·6
Dark	¾	75	3,550	·325		
	None.		3,330	·315		
			gain 220	·010	6·6	3·1
Dark	½	100	3,430	·330		
	None.		3,100	·300		
			gain 330	·030	10·60	10·0

is lower in silicon than British brands, and that higher melting ratios are more common there than here, combined with stronger blast, some considerable absorption of oxygen is a constant occurrence in their practice. Even if this be so it is a question whether it would not be more economical to work with slightly lower melting ratios, and with more flux on the charge, than to incur the expense of silicon additions to the ladle.

Grading Pig Iron for the Foundry.—Mr. P. Munnoch, in dealing with grading before the British Foundrymen's Association, states at the outset a difficulty in the way of definition, for the grade does not depend entirely upon the amount of any one element, but on a combination of several. Taking a broad view of the matter from No. 1 through the several grades down to white iron, it will be seen that sulphur is practically the controlling element. This controlling power is modified to a more or less extent by the relative amounts of the other constituents, but chiefly by the amount of total carbon present. The total carbon must, however, be considered in relation to the phosphorus present, and also, to some extent, to silicon when much above or below the normal amount is present. Practically silicon varies more than any other element, and although it has a great influence on the properties of castings, it has very little influence on the grade of pig iron as determined by fracture. It is thus possible to obtain pig irons almost identical in fracture, and therefore similar in grade, which may contain from 1 to 4 per cent. of silicon, and even greater variation than this is possible. Sulphur also varies, but the limits are more readily defined, and there is a regular increase. In actual practice it is found that the sulphur is generally within certain limits, and the fracture to a great extent indicates the sulphur. Total carbon also varies, and, in conjunction with sulphur, practically governs the grain. Where total carbon is low the grain is smaller than indicated by the sulphur present. Total carbon should be considered in conjunction with phosphorus, as an iron low in phosphorus will carry more carbon than a phosphoric iron. Usually 1·5 per cent. phosphorus displaces about 0·5 per cent. carbon. The author then quotes and tabulates a series of variations which show the difficulty of drawing up a table to include all variations from the normal. Finally, the conclusion reached is that the best system of grading, both for foundry and blast furnace, is one in which the grade is based upon a fixed scale of sulphur contents. The table below gives proposed sulphur limits, the grade numbers being those in general use in the Cleveland district.

Blowholes in Steel Castings.—Mr. W. M. Carr, writing in the *Iron Trade Review*, draws at first a distinction between blowholes and shrink holes. The walls of a shrink hole are usually the same colour as that of the metal, provided air has been absent. Blowholes are the result of air, vapour or gas, and in form may be oblong, lenticular or spherical. If oblong they are due to the steel being improperly deoxidised or killed, and they will be found with their longest dimensions at right angles to the cooling surface. If they are globular or spherical they are caused by vapour or air resulting from damp sand or imperfect venting—that is, faults of moulding and not composition. If the green sand mould should possess the right temper, and globular or spherical holes still be found in the casting, their presence may be due to two causes. The sand, whether green or dry, may be too close or strong, thus preventing a free escape of the gases as they are formed by the heat of the inflowing steel. Evidence of this is shown in fractured castings having a solid drag side, but a more or less porous cope side. Porosity may be also caused by failure to freely vent the highest points of the cope, which will result in the formation of air pockets, a feature common to dry or green moulds filled with properly deoxidised steel. If the analysis is normal—that is, manganese and silicon, are within usual limits, but blowholes of the oblong character are persistent—the cause may then be traced to furnace conditions. There may have been too sharp a melting flame, too much air admitted for combustion, or a too liberal use of ore in running down the charge. Any one of these conditions will surcharge the metal with oxide beyond the influence of the usual addition of deoxidisers, such as manganese or silicon. Such practice may be covered up or lessened by increased additions of deoxidiser, but this is at the sacrifice of that essential in all steel castings—toughness. Finally, whilst it is possible to produce in green or dry moulds, from acid or basic steel, castings free from blowholes or

Grade.	Sulphur.	Special Low.	Low.	Silicon, Standard Quality.	High.	Special High.
No. 1	not over ·04	below 1·8	1·8 to	2·5 to 3·3	to 4·0	above 4·0
No. 2	,, ,, ·04	,, 1·8	1·8 ,,	2·5 ,, 3·3	,, 4·0	,, 4·0
No. 3	,, ,, ·06	,, 1·5	1·5 ,,	2·2 ,, 3·0	,, 3·8	,, 3·8
No. 4 (foundry)	,, ,, ·08	,, 1·3	1·3 ,,	1·8 ,, 2·6	,, 3·3	,, 3·3
No. 4 gray forge	,, ,, ·12	,, 1·0	1·0 ,,	1·5 ,, 2·0	,, 2·8	,, 2·8
No. 4 hard forge	,, ,, ·1	—	·80 ,,	1·3 ,, 1·8	,, 2·5	,, 2·5
Mottled	,, ,, ·28	—	below	1·0 ,, 1·5	above 1·5	
White	all over ·28	—	,,	·5 ,, 1·0	,, 1·0	

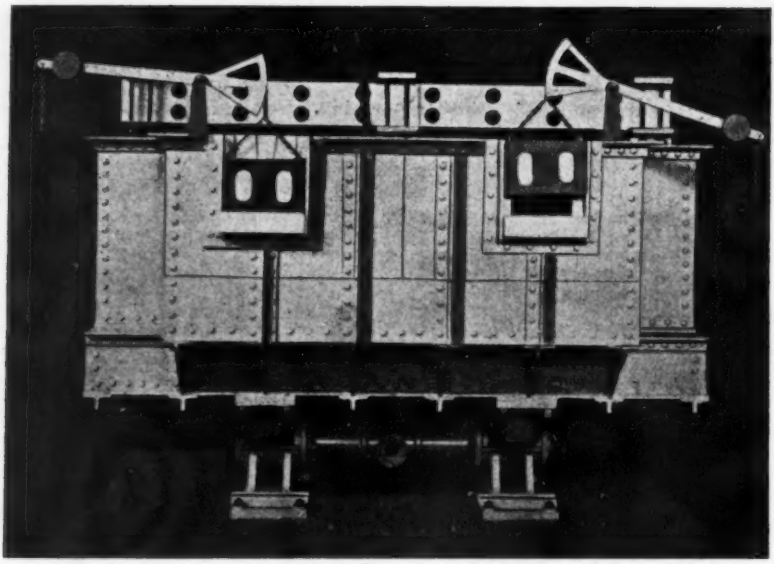


FIG. 6.—LATEST TYPE OF THE GIN ELECTRIC STEEL FURNACE.

pin holes, the writer notes that there is no royal road to the production of sound steel castings. This road can only be traversed by patience, skill, industry and study.

STEEL: ITS PROPERTIES, TREATMENT AND PRODUCTION.

The Gin Electric Steel Furnace.—We have previously noted this furnace, but a recent article by Mr. F. Perkins, in *The Mining World*, gives further details. Fig. 6 shows the latest type of furnace designed by Gustave Gin for the Electric Iron and Steel Works, Plettenberg, Westphalia. It is claimed that this plant has an output of 350 tons per 24 hours, the furnaces taking 7,200 kilowatts, a current of 60,000 amperes at 120 volts being utilised. The doors of the furnace illustrated are operated by counter weights, and an electric motor is used to tilt the furnace on its central bearings at the base. The finished metal is poured through the opening *K* (Fig. 7) placed in front of the furnace and opposite the electrical connections *F* and *E*. The furnace has a semicircular bottom at *A* with a sinuous course. The multiple furnace combines the simultaneous and continuous working of the complete processes for the production of steel: fusion, oxidation of impurities and recarburisation, as well as reduction of the dissolved oxide of iron in the bath. It is stated that the furnace will permit of the easy manufacture of special steels by direct addition of manganese, nickel or tungsten, whilst special grades of high manganese and low carbon contents may be obtained by the suitable addition of silicon and manganese.

GENERAL METALLURGY.

Recent Progress in Metallurgy.—Mr. A. E. Outerbridge, in an address to the Franklin Institute, discusses some aspects of recent progress. Commencing with a reference to the "Gayley" dry air process, the author passes on to a consideration of pig iron, showing that the *per capita* consumption in the United States has risen to 620 lbs., as compared with 68 lbs. as the average consumption of the total production of the world in 1905.

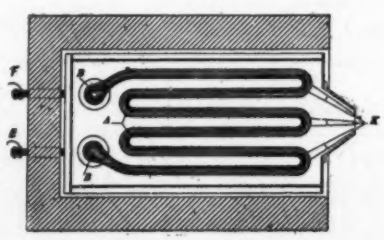


FIG. 7.

Considerable progress has been made in the recovery of waste products, and in this direction the prospective utilisation of blast furnace slag in the manufacture of high grade cement is exceedingly promising. This possibility has been talked of for years, but unfortunately the sulphur in the slag is a deleterious element. It is said that the United States Steel Corporation has recently perfected a process for eliminating sulphur and making fine cement from slag. The use of ferro alloys in the manufacture of high speed steels has made great progress during the past year, and has been extended in various directions with remarkable results. Large and costly milling cutters are now made of these steels, as well as planer and lathe tools and drills. Improved methods of hardening and tempering these steels have also been devised. The use of ferro alloys in the foundry is likewise extending, and the author makes special reference to his experiments on the addition of high grade ferro silicon to molten cast iron. In addition to the material improvement in the strength of the metals by these additions, there is a decided decrease in shrinkage, so that some castings of irregular shape which are difficult to make without cracking, owing to unequal strains, are now made without this tendency by the addition of silicon. Other advantages accruing from the addition of small amounts of 50 per cent. ferro silicon have been observed. Among these may be mentioned the cleaning action upon the molten metal which the alloy effects by its deoxidising influence. Singularly, also, it is found that commercially pure silicon does not produce these results, neither does the ordinary grade of ferro silicon containing about 20 per cent. silicon.

The increase in production of copper in the United States is described as astounding, for whilst in 1880 one-sixth of the world's output was produced, in 1905 this had risen to more than one-half of the total output. Increased output has been stimulated by increased demand, but the price of copper has risen coincidently with increase in production, notwithstanding the fact that modern methods have greatly reduced the cost of copper refining. The electrolytic process is one of extreme simplicity: it depends primarily upon the passage of an electric current between two plates of copper suspended in a tank containing copper sulphate in solution. As only the copper in the crude metal can act as a carrier of the current, the impurities are left behind, and pure copper alone is deposited on the plate of metal by which the current leaves the vat. The impurities frequently consist of gold and silver in sufficient quantity to more than pay all cost of refining the copper by this process.

New Machinery and Appliances.

10-ft. High-speed Electrically-driven Radial Drilling Machine.

A fine example of a radial drilling machine has recently been completed at the works of Messrs. Wm. Asquith, Ltd., Halifax, a view of which is presented in the accompanying illustration.

At the outset it should be stated the illustration does not do justice to the machine, the photograph having had to be taken from an unfavourable position, owing to the inconvenience of moving other heavy machines being erected at the same time on the same floor.

The arm is of the firm's patent central thrust type, double webbed, of very deep section, with great length of bearing upon the sleeve. It is stated that this form of arm cannot be twisted sideways under any duty, as in other forms where the spindle is overhung. Its rigidity and resistance to end lift will be apparent from the illustration.

The spindle slide has right angular bearings upon the under sides of the arm, and is of very durable construction for maintaining accuracy. It can be easily and quickly traversed along the arm by hand motion, and securely locked in any position. The slide carries a double gear, a lever for stopping, starting or reversing the spindle, an antomatic trip motion, gear feed box, and motion for radiusing the arm. The latter motion is of a simple and efficient design, being through a large hand wheel which is handily placed on the spindle slide, worm and gears, as shown in the illustration. The arm can thus be finely and accurately adjusted by the operator without leaving his working position. The motion can be thrown out of gear when desired, thus allowing the arm to be quickly swung round by hand.

The arm is mounted upon strong section cylindrical pillar or sleeve, which has top and bottom bearings of very large diameter

and great length. The sleeve is supported by a strong box section pillar or standard, with a large base, firmly secured to the foundation plate. The strength and rigidity of this arrangement of sleeve and standard is obvious, and in combination with the firm's improved arm renders the machine particularly immune from undue spring or deflection.

The arm has power raising and lowering motions, the maximum height under the spindle when in the top position being 7 ft. 3 ins., with a vertical arm adjustment of 3 ft. 6 ins.

The spindle is 3½ ins. diameter, having 20 ins. hand and variable self-acting feed motion. There are eight changes of feed motion, instantly variable through gears, and by means of a powerful friction drive, the speed can be instantly applied or withdrawn when the spindle is ready for quick raising or lowering, being balanced. For repetition drilling of equal depths, automatic trip motion is provided, with a dial index reading up to 20 ins., and a safety stop to prevent overtraverse.

The spindle is carried in a large diameter sleeve, which firmly supports it when out at full traverse, and ball bearings are provided to take the thrust when drilling. The end of the spindle is bored Morse's standard taper No. 6 for receiving drills, sockets, and

10-FT. HIGH-SPEED ELECTRICALLY DRIVEN DRILLING MACHINE.

boring bars. The spindle has a reversing motion under immediate control for tapping and inserting studs, and reversing is accomplished at a much quicker speed than when tapping. The double gear can be thrown in or out by a lever under immediate control, carried on the slide.

Driving is effected by a motor, mounted on top of the standard. The motor is of the variable speed type, and by means of shunt regulator a large range of speeds can be obtained, which, of course, the double gear multiplies. There is thus a very large number of spindle speeds, correctly graded, without undue jumps and under easy control.

The baseplate is 7 ft. long by 6 ft. wide, and very deep and strongly ribbed. The arm has a radial adjustment through 150 degrees, 90 degrees to the front and 60 degrees to the back. The sleeve upon which the arm swings rotates upon a large ball race, making this motion very easy to operate.

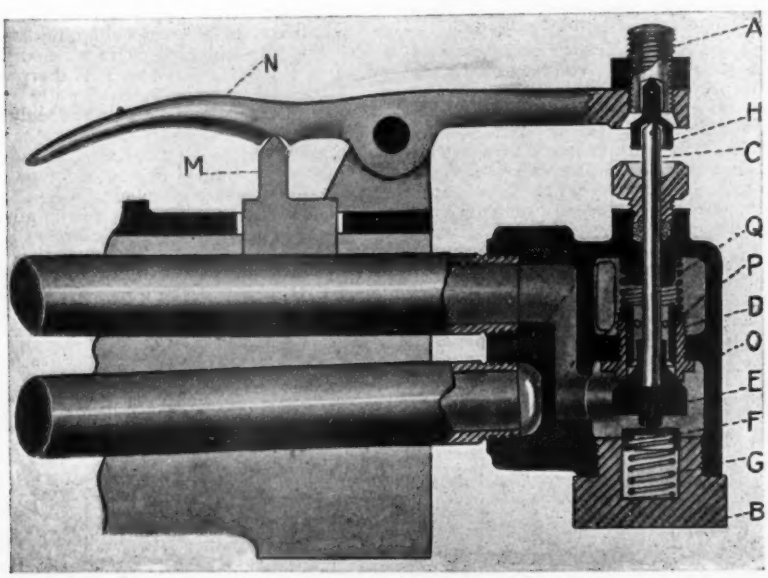
The machine is one of two recently supplied to a large Ordnance Works. Its overall height is 18 ft. 6 ins., and the weight about 20 tons finished, without the work table.

The "Geipel" Rapidity Type Steam Trap.

That familiar apparatus known as the "Geipel" steam trap has recently been the subject of various improvements, which, while retaining the advantages attaching to the expansion parts of Mr. Geipel's older design, have produced a trap which is stated to be greatly superior thereto. The feature of the older pattern, and which has been retained in the new, is the method by which the expansion is multiplied without the use of levers, cranks, or pivots.

The following are the points constituting the improvements:—The valve is rearranged in such a way that it is held on its seat by the steam pressure, consequently a valve of much larger area can be used than in the ordinary trap where the valve is closed against steam pressure: the valve is of the rotating type, so that every time a discharge takes place the valve tends to grind itself in; the action of the valve is such that, when blowing through, it is forced well off its seat to give the maximum opening.

In order to obviate the noise, straining and cutting of the rapid discharge which



THE "GEIPEL" RAPIDITY TYPE STEAM TRAP.

results from the large opening through which the water is forced under high pressure, an arrangement is provided which automatically reduces the velocity of the water; this throttle comes into action under high pressures, but not under low pressures; in other words, this trap gives a full-bore discharge whether the pressure is low or high, without causing undue noise or destruction at high pressure.

The usual "Geipel" hand-blow-through is provided, and the valve can be got out for inspection and cleaning by simply removing the valve cover, without interfering with steam connections or other parts of the trap.

There is the further advantage that it will work without re-adjustment under considerably greater ranges of pressure than the ordinary "Geipel" trap.

The brass tube which constitutes the inlet is at the top of the trap, and the iron tube which constitutes the outlet for the discharge is at the bottom. This arrangement is the converse of the ordinary "Geipel" trap, and makes a more convenient disposition for the inlet and outlet. The two tubes are fixed at one end as heretofore, and are free to move at the opposite end where the valve is fixed.

The details will be readily understood by referring to the accompanying sectional illustration.

The valve *E* is held normally on its seat by the steam pressure combined with the pressure of a light spring *G*. When the trap is cold or full of water, the valve is depressed from its seat by the valve spindle *C*, which abuts against the end of the lever *N*. When steam enters the brass tube the latter expands and moves the valve casing *O* downwards. The steam pressure and light spring then close and hold the valve tight until water has again entered the brass tube and cooled it, upon which the brass tube contracts and moves the valve casing upwards until the valve spindle *C* impinges on the lever and forces the valve open. As soon as the valve is open the rush of water forces or wedges the valve downwards, thus making the large opening which gives the rapid discharge. So rapid indeed is the discharge, that the automatic throttling device above referred to has been found desirable at high pressures, in order to avoid shock, strains and noise. This device consists of a movable bush *P*, controlled by a spring *Q*; its action is automatic, so that when the trap is discharging at low pressure, as for example, when steam is first turned on, the bush does not tend to throttle, but when the pressure rises and there is an increased discharge, the friction thereof moves the bush in an upward direction against the action of the spring, thus reducing the aperture of the discharge and consequently its velocity.

The valve *E* is separate from the valve spindle and is therefore not held fast by the friction of the stuffing box; further, being provided with veins, it is caused to rotate whilst discharging, and consequently to grind itself in at each discharge so that the seat is kept in good order.

The action of the trap is stated to be such that there is no dribbling, but as soon as the trap commences to discharge the valve is forced well open. A sharp blow-through then occurs until all water is discharged, when the trap is as suddenly shut.

The trap will work with ranges of pressure, without adjustment, considerably greater even than in the old type. For example, the trap adjusted to close at 60 lbs. will work up to 150 lbs., or a trap adjusted at 90 lbs. will work up to 180 lbs.

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